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CHARDONIELLA—A NEW GENUS OF THE UREDINALES¹

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(WITH 3 FIGURES)

In March 1937, Dr. C. E. Chardon sent me from Colombia a fine specimen of rust which he had labeled as being on *Gynoxis*, a genus of the Compositae known from the Andes of tropical South America. It was natural to think at once of *Chrysopsora Gynoxidis* described by Lagerheim from Ecuador many years ago (Ber. Deuts. Bot. Ges. 9: 345. 1891). But *Chrysopsora* has ring-shaped sori of a low pulvinate form. The rust at hand had elongated hair-like sori. It did not have any of the external characters of *Chrysopsora*.

This fact made one suspicious of the host determination. Then began an effort to get additional material so that the host could be checked carefully. The attempt was successful and finally a specimen was obtained with flowers and rusted leaves on the same shoot. I am indebted to Dr. S. F. Blake for his examination of this specimen. He confirmed the determination of *Gynoxis* but was unable to name the species with the material at hand.

The macroscopic characters of the rust, as already indicated, made a reference to *Chrysopsora* impossible. Microscopic characters confirmed this. *Chrysopsora* has two-celled spores with an internal promycelium. Our specimen has one-celled spores with an external promycelium. The spores are borne on stalks 80–125 μ or more long.

¹ Contribution from the Department of Botany, The Pennsylvania State College, No. 118.

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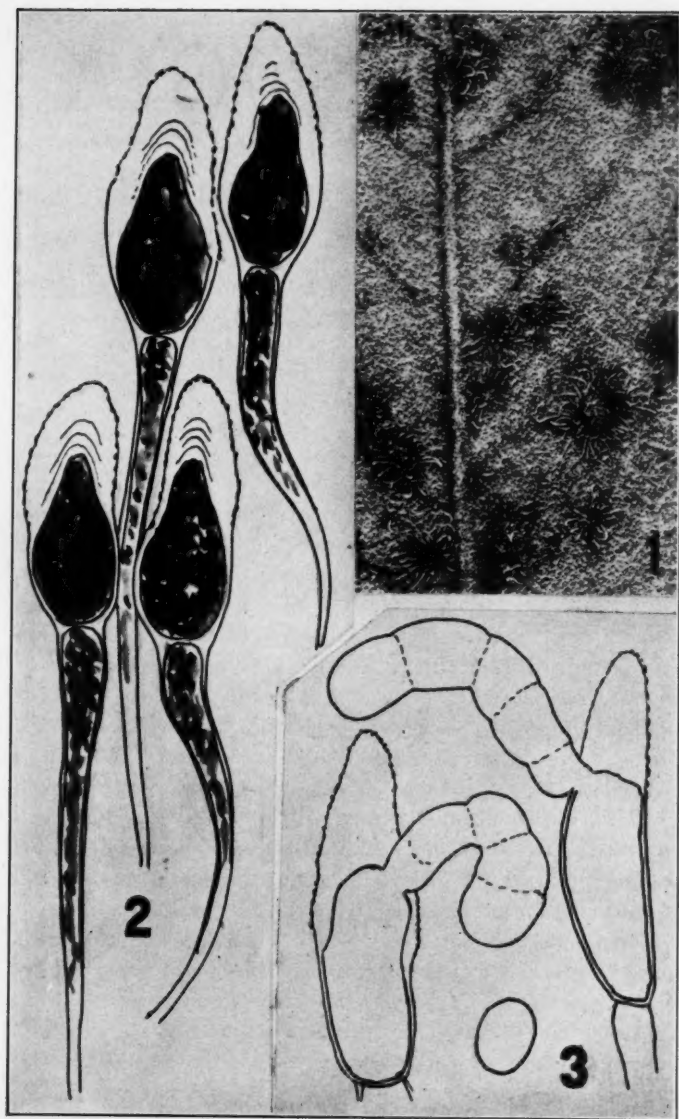


FIG. 1, microphotograph of telia on the undersurface of leaf, $\times 3$ (photo by Dr. L. O. Overholts); 2, four teliospores, with their long pedicels, illustrating the manner in which the spores are crowded together in the sorus; 3, two spores germinating, showing the 4-celled promycelia, below—the outline of a single basidiospore.

With stalked spores more or less united laterally we have characteristics of the family Pucciniaceae. To place it in a tribe is not so easy. It has some of the characters of the Puccinosireae except that the spores do not seem to be in chains. If they are in chains then what I interpret as stalks are long intercalary cells. These cells are filled with orange-yellow contents as are the spores themselves. The contents give a coarsely granular appearance and large oil droplets are evident.

I have tried to see a resemblance of this *Gynoxis* rust to the genus *Trichopsora*. But *Trichopsora* has spores in chains, with an evenly thick wall, and an internal promycelium. This specimen has stalked spores, with wall much thicker above, and an external promycelium. The resemblance to *Trichopsora* seems to be superficial only. There is an external resemblance to *Cronartium* or *Cionothrix* but those genera have small spores in evident chains without either stalks or intercalary cells. Again the resemblance is purely a superficial one.

I have pleasure in dedicating this new genus to Dr. Carlos E. Chardon, who has contributed so much to our knowledge of the rusts and other fungi of the tropics of the western hemisphere.

Chardoniella gen. nov.

Pycniis subepidermalibus; periphysibus instructis. Teliis subepidermalibus, erumpentibus in columellam plus minus elongatam cylindraceam vel filiformem, massam siccam corneamque formantibus, teliosporis unicellularibus pedicellatis; promycelio externo typice 4-cellulari.

Chardoniella Gynoxidis sp. nov.

Pycniis epiphyllis, in centro macularum decoloratarum aggregatis, profunde insidentibus, globosis vel piriformibus, 175–225 μ latis; periphysibus fasciculatis, prominentibus, 80–100 μ vel longioribus.

Teliis hypophyllis, in greges coronarias 1–5 mm. diam. dispositis, columellam elongatam cylindraceam formantibus, 2–2.5 mm. longis, flavis vel aureo-flavis; teliosporis ellipsoideis vel obovatis, 24–32 \times 55–69 μ , infra rotundatis vel truncatis, supra plerumque angustatulis; membrana hyalina, 1–1.5 μ cr., ad basim leve, ad apicem valde incrassata, 19–26 μ , obscure laminata; pedicello hyalino, in parte inserta 12–15 μ lato, deorsum attenuato, sporae duplo-aequante vel longiore. Basidiosporis late ellipsoideis, 15–16 \times 19–23 μ .

Hab. in foliis *Gynoxidis* spec., Cerro Montserrate pr. Bogota, alt. 2750 m., Colombiae, mense Martii, 1937, C. E. Chardon (no. 829).

DEPARTMENT OF BOTANY,
THE PENNSYLVANIA STATE COLLEGE

A STUDY OF SOME AQUATIC PHYCOMYCETES ISOLATED FROM MEXICAN SOILS¹

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(WITH 4 FIGURES)

Although Butler (1907) discovered more than thirty years ago that species of *Pythium* could be isolated from the soil, it was not until the application of Butler's cultural methods by Harvey (1925) that the widespread occurrence of the Saprolegniaceae and other water molds in the soil was generally appreciated. Subsequently, the phycomycetous soil flora has been studied in various parts of the world. Coker and Braxton (1926), Coker (1927), and Raper (1928) have made a series of studies of terrestrial forms of the Saprolegniaceae and closely related groups in North Carolina, Couch (1927) has isolated aquatic fungi from soils in New York, and Harvey (1927, 1928, 1930) has investigated the water molds occurring in Wisconsin soils, as well as those of Oklahoma, Mississippi, and Kentucky.

The studies of Apinis (1930) in Latvia, Dissmann (1931) in Austria, Barnes and Melville (1932) in England, Cook and Morgan (1934) and Morgan (1938) in Wales, Höhnk (1935) and Richter (1937) in Germany, Nagai (1931) in Japan, and Cookson (1937) in Australia have shown that saprolegniaceous fungi as well as other groups of the aquatic Phycomycetes are widely distributed in soils throughout various parts of the world. These investigations have further demonstrated that while certain species previously found only in water are also quite common in the soil, other forms, including species of the genera *Brevilegnia* and *Geolegnia*, are apparently adapted for a strictly terrestrial mode of existence, and are to be found only as constituents of the soil microflora. Höhnk (1935) has clearly correlated the number of motile stages of the zoöspores in various genera of the Saproleg-

¹ Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. 169.

niaceae with the aquatic and terrestrial habits of these forms. Cook and Morgan (1934) have even been so impressed by the wide distribution and common occurrence of the Saprolegniaceae in the soil as to suggest that the term "water molds" as a common name for these fungi will ultimately have to be given up.

Apparently no collections of the aquatic Phycomycetes have ever been made in Mexico, either from water or from soil. During August, 1937, sixty samples of Mexican soils, chiefly from river beds and other moist situations, were collected by the author. The territory represented by these collections extends along the Pan American Highway (Camino Nacional no. 1) from Laredo, Texas to Mexico City. In addition, a number of collections were made in the vicinity of Cuernavaca. Inasmuch as the territory from which collections were made is a large, sparsely populated one, and towns or other suitable landmarks were often lacking, the "mileposts" along the highway, giving the distance (in kilometers) to Mexico City were often used to designate the localities from which soil samples were collected. The approximate locations of the sources of the soil samples from which aquatic fungi were isolated may be seen from the accompanying map (FIG. 1).

The soil samples, collected in small glass vials, were subsequently brought into the laboratory, placed in sterile Petri dishes, covered with sterile distilled water, and boiled hemp seeds were introduced as a substratum. From eleven of the soil samples cultured in this manner, aquatic Phycomycetes, including representatives of the Blastocladiaceae, Saprolegniaceae, and Leptomitaceae, were isolated. The present paper, concerned with the identity, morphology, and development of these fungi, is based upon a study of hemp seed cultures over a period of nine months.

The family Blastocladiaceae was represented by six isolates, all belonging to the genus *Allomyces* (Butler, 1911). These *Allomyces* isolates were studied culturally and biometrically by Dr. Ralph Emerson, at the Botany School, University of Cambridge, England, to whom the author is indebted for practically all of the information presented herein concerning them.

Emerson (1937, 1938) has demonstrated the existence in the genus *Allomyces* of three distinct types of life cycles, and has therefore proposed the classification of the various species into

subgenera based upon their life cycles. All species of *Allomyces* produce thin walled sporangia, as well as the characteristic thick walled resistant sporangia. In the subgenus *Euallomyces*, which includes *A. javanicus* Kniep (1929, 1930) and *A. arbuscula* Butler

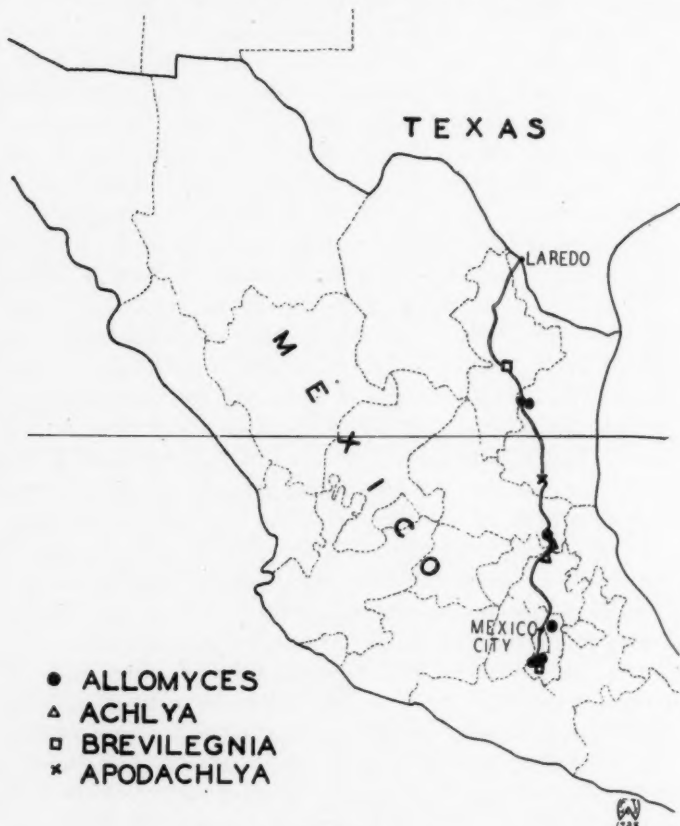


FIG. 1.

(Hatch, 1933, 1935), zoöspores from germinating resistant sporangia develop into plants bearing male and female gametangia. There is thus a regular alternation of asexual and sexual generations in this life cycle. In the subgenus *Cystogenes*, on the other hand, which includes *A. moniliformis* Coker and Braxton (1926),

zoöspores from resistant sporangia encyst upon emergence, and the cysts germinate to give rise to groups of four zoöspores, each of which develops into an asexual plant bearing resistant sporangia. These two subgenera are further differentiated upon the basis of the pitting of the walls of the resistant sporangia: in *Euallomyces*, the pits are fine and closely spaced, whereas in *Cystogenes* the pits are larger, more prominent, and more widely spaced. A third subgenus, *Brachyallomyces*, has been tentatively proposed for a number of isolates which apparently have no sexuality and do not form cysts. These forms are characterized by the complete omission of the gametophyte generation from the life cycle.

Observational evidence, confirmed by a series of 100-150 measurements of the length and width of the resistant sporangia of the Mexican isolates of *Allomyces*, showed that the six isolates fell into three morphological types. It may be observed (FIGS. 2, 3) that measurements of the resistant sporangia of isolates no. 26, no. 29, and no. 37 are in close agreement, while isolates no. 16 and no. 17 are very similar to each other, and isolate no. 46 differs markedly from the others. These differences are further borne out by an examination of the pitted walls of the resistant sporangia (FIG. 4). Isolates no. 16, no. 17, no. 26, no. 29, and no. 37 have resistant sporangia whose walls are provided with the fine, closely spaced pits characteristic of the subgenera *Euallomyces* and *Brachyallomyces*. In isolate no. 46, however, the wall of the resistant sporangium has larger, more obvious, and more widely spaced pits, as in the subgenus *Cystogenes*.

Supplementary to the morphological studies of the asexual, resistant sporangium-producing plants, attempts by Dr. Emerson to secure germination of the resistant sporangia were successful in four of the six isolates, so that complete life cycles were obtained. These four isolates can therefore be definitely identified. Germination experiments with resistant sporangia of the remaining two isolates have not yet been carried out in sufficient number to justify specific designation.

The following species of the genus *Allomyces* (Blastocladiaceae) were collected:

ALLOMYCES ARBUSCULA Butler (1911)

Two collections were made of this species. One (no. 29) was collected from moist soil in the Borda Gardens, Cuernavaca, on August 16, 1937; the other (no. 37) was found in a roadside ditch near Tepexpan, 6 km. east of Venta de Carpio, on August 18. As may be seen from the data presented (FIGS. 2, 3, table 1)

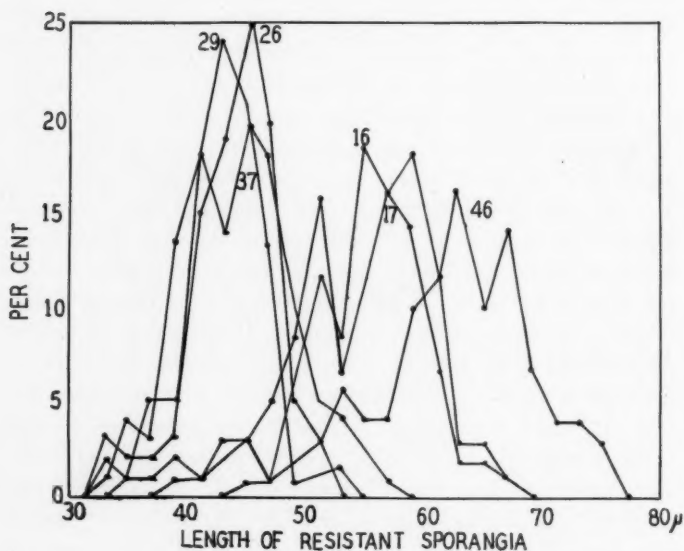


FIG. 2. Length of the resistant sporangia of the various isolates of *Allomyces*.

TABLE 1

COMPARATIVE MEASUREMENTS OF THE RESISTANT SPORANGIA
OF THE ISOLATES OF *Allomyces*

Isolate	Number of measure- ments	Mean width (μ)	Mean length (μ)	75% or more between	
				Width (μ)	Length (μ)
<i>A. arbuscula</i> (No. 29)....	100	33	43	28-38	38-48
<i>A. arbuscula</i> (No. 37)....	100	33	45	28-38	40-50
<i>A. anomala</i> (No. 26)....	100	33	44	28-37	38-48
<i>A. moniliiformis</i> (No. 46)..	100	35	63	31-38	54-70
<i>A. sp. indet.</i> (No. 16)....	150	42	56	33-48	45-61
<i>A. sp. indet.</i> (No. 17)....	150	42	55	34-48	46-61

resistant sporangia of these two isolates are very similar to each other in size. The walls of the resistant sporangia are ornamented with the pitting characteristic of *Euallomyces*. Upon germination of the resistant sporangia of these isolates, zoöspores were produced which gave rise to sexual plants bearing gametangia characteristic of *A. arbuscula*. The brightly pigmented male gametangia are hypogynous in position, as described for this species by Hatch (1933, 1935).

ALLOMYCES ANOMALA Emerson (1937, unpublished)

This species was isolated (no. 26) from soil collected on August 16 from the Borda Gardens, Guernavaca, a locality in which *A. arbuscula* was also found. As regards the size of the resistant sporangia and characteristics of their pitting, this isolate is indistinguishable from *A. arbuscula*. Upon germination of the resistant sporangia, however, the zoöspores invariably give rise to asexual plants. A sexual stage is presumably entirely omitted from the life cycle, as is apparently the case in at least one species of the closely related genus *Blastocladia* (Blackwell, 1937).

This isolate clearly belongs, therefore, to the subgenus *Brachyalomyces*. There is but a single species, *A. anomala*, based on two collections made by Emerson, one from Stowe, Texas, and the other from Hupeh, China. Whether or not other early isolates of *Allomyces*—such as the original form of Butler (1911)—which were studied before the discovery of sexuality in the genus, may actually belong to this species, remains problematical.

ALLOMYCES MONILIFORMIS Coker & Braxton (1926)

This rare species of *Allomyces* was collected once (no. 46) from the Rio Axtla, at its intersection with C. N. 1, 399 km. north of Mexico City, on August 20. Resistant sporangia of *A. moniliformis* (FIG. 2, 4) are more elongate than in other species of the genus, and a large proportion of these thick walled sporangia are bluntly pointed at the apex, in marked contrast to the broadly rounded shape of the resistant sporangia of *A. arbuscula*. Furthermore, the pitting of the walls of the resistant sporangia is of the larger, more obvious, more widely spaced type as described above.

The life cycle of isolate no. 46 conforms to that described for the subgenus *Cystogenes*—to which *A. moniliformis* belongs—by Emerson (1937, 1938). Although the resistant sporangia are slightly larger than in the original material described by Coker and Braxton (1926), it seems clear that the present isolate is actually *A. moniliformis*.

This species has previously been found only in North Carolina, by Coker and Braxton (1926) and Coker (1927).

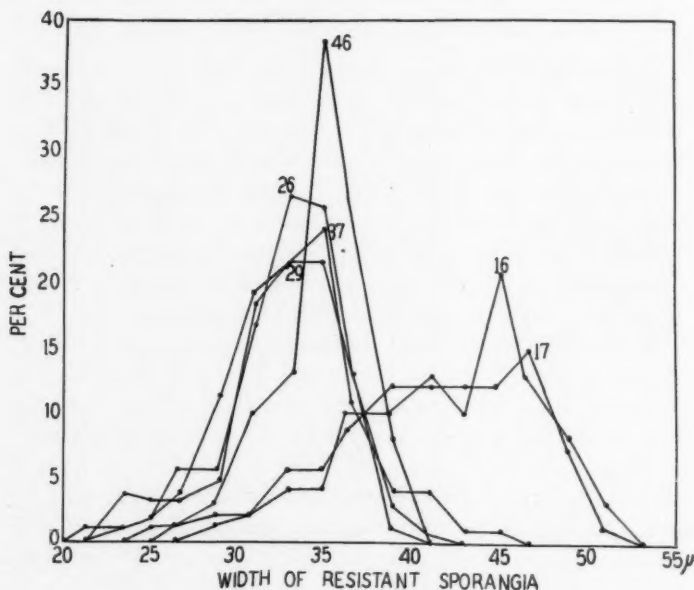


FIG. 3. Width of the resistant sporangia of the various isolates of *Allomyces*.

ALLOMYCES sp. indet.

Two isolates (no. 16, no. 17) from soil collected at the Rio Pilon at its intersection with C. N. 1, 833 km. north of Mexico City, on August 13, belong to an undetermined species of *Allomyces*. Resistant sporangia from these two collections are so similar to each other in size and appearance that the two isolates are very probably identical. These resistant sporangia are consid-

erably larger than in the Mexican material of *A. arbuscula* and *A. anomala*, and the pitting is of the type characteristic of the subgenera *Euallomyces* and *Brachyallomyces*, as contrasted with *Cystogenes*.

Since resistant sporangia of these two isolates have proved difficult to germinate, experiments to determine the life cycle have not yet been successful. If a sexual stage is ultimately found, it will probably be of the *A. arbuscula* type, as no species with

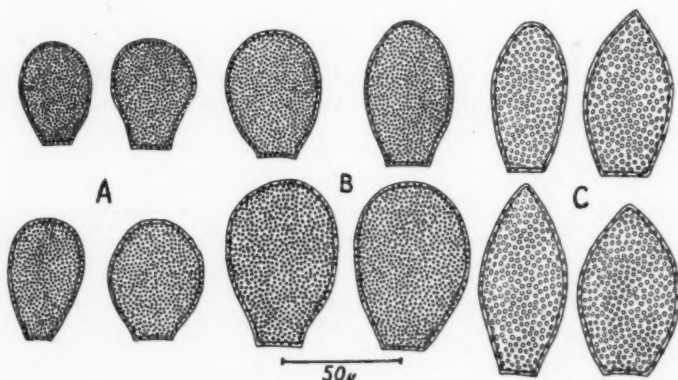


FIG. 4. Resistant sporangia of the isolates of *Allomyces*. A, *Allomyces arbuscula* (resistant sporangia of the isolate of *A. anomala* are indistinguishable from these); B, *Allomyces* sp. indet.; C, *Allomyces moniliformis*.

epigynous male gametangia has as yet been found in the western hemisphere (Emerson, 1937). There is also the possibility, as seems more probable, that these isolates represent unusually large forms of *A. anomala*, or that they may belong to an undescribed member of the subgenus *Brachyallomyces*.

In addition to the species of the Blastocladiaceae just discussed, a few forms belonging to the Saprolegniaceae were also collected:

ACHLYA CONSPICUA Coker (1923)

This species was collected once (no. 48) from soil near the Rio Coy, at its intersection with C. N. 1, 444 km. north of Mexico City, and once (no. 53) from soil in an arroyo intersecting C. N. 1, 501 km. north of Mexico City, on August 20. Both collections

were found to agree closely with Coker's original description. *A. conspicua* has previously been isolated from soil in North Carolina (Coker, 1927).

BREVILEGNIA DICLINA Harvey (1927)

This species was collected once (no. 10) from soil near the Rio de Montemorelos, at the intersection of C. N. 1, 915 km. north of Mexico City, on August 13. It appears to be fairly widely distributed in soils in various parts of the United States (Harvey, 1930) and has also been reported from Europe (Cook and Morgan, 1934).

BREVILEGNIA SUBCLAVATA Couch (1927)

This species was found once (no. 28) in soil from the Borda Gårdens, Cuernavaca, on August 16. *B. subclavata* has previously been collected only by Couch from Long Island, New York, the source of the material from which the species was originally described. The very dense, compact, restricted growth on hemp seed, the short-clavate shape of the sporangia, the non-motility of the spores, and the characteristics of the sexual organs in the Mexican isolate were found to agree in all essential features with Couch's original description.

The family Leptomitaceae is represented in the present series of collections by a single species of *Apodachlya*:

APODACHLYA PYRIFERA Zopf (1888)

This species was isolated (no. 60) from soil collected near the Rio Frio, at its intersection with C. N. 1, 587 km. north of Mexico City, on August 20. The sporangia of this isolate are somewhat variable in size and shape, and the zoospores regularly encyst at the mouth of the sporangium upon emergence. This represents the first instance known to the author in which this species, previously known from water in Europe, New York, and Massachusetts, has been found to occur in the soil.

DISCUSSION

Inasmuch as no studies of the aquatic Phycomycetes of Mexico have been made prior to the present report dealing with only a

few of the soil forms, no very general conclusions may yet be drawn. There are, however, a few points of interest in connection with this relatively small number of collections, even though the latter cannot be considered to offer more than a fragmentary picture of the phycomycetous soil flora of the region.

The small proportion of successful isolates from the soil samples collected by the author may be explained by the fact that the samples were kept for a period of six weeks before an opportunity to culture them was obtained. This delay would also seem to explain the great preponderance of isolates of *Allomyces*, ordinarily considered a relatively rare genus, in the present collections. The presence in *Allomyces* of thick walled resistant sporangia afford it a much greater chance of survival under adverse conditions than is obtained with forms having no such structures adapted for persistence.

Allomyces is primarily a genus of the warmer climates. Various species have been found in the tropical regions of both the eastern and western hemispheres (Knipf, 1929, 1930; Emerson, 1937), and the northernmost limit of its range is reached in Wisconsin and New York. In view of these facts, it does not appear surprising, therefore, that species of *Allomyces* seem to be of rather common occurrence in Mexico. Since *A. moniliformis* has been reported from North Carolina and from Cuernavaca, Mexico, there is reason to believe that this species is not of rare occurrence, and future studies will disclose other intermediate localities in which it is to be found.

The distribution of *Brevilegnia diclina*, previously known from various parts of the United States and from Europe, and of *B. subclavata*, previously found only in New York, also indicate a notable lack of endemism in the distribution of these aquatic fungi.

There are undoubtedly many more species of aquatic fungi to be found in Mexico. Such places as the floating gardens at Xochimilco, in which the water is rich in organic matter and plant refuse to furnish likely substrata, would seem to offer an exceedingly favorable collecting ground for future investigation.

SUMMARY

No previous studies have been made of the aquatic Phycomycetes of Mexico. From a series of sixty soil samples collected from various localities in Mexico in August, 1937, the following aquatic fungi were isolated:

Blastocladiaceae—*Allomyces arbuscula*, *A. anomala*, *A. moniliformis*, and *Allomyces* sp. indet.

Saprolegniaceae—*Achlya conspicua*, *Brevilegnia diclina*, and *B. subclavata*.

Leptomitaceae—*Apodachlya pyrifera*.

The study of these collections was begun with the support of an Alumni Research Fellowship from the University of Wisconsin, and was completed at Harvard University during the tenure of a National Research Fellowship. The writer is deeply appreciative of the collaboration of Dr. Ralph Emerson in studying the isolates of *Allomyces*. Nor would the completion of the author's portion of this investigation have been possible without the continued encouragement and helpful suggestions of Dr. E. M. Gilbert and Prof. Wm. H. Weston, Jr., under whom this work was done.

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LITERATURE CITED

- Apinis, A.** 1930. Untersuchungen über die in Lettland gefundenen Saprolegniaceen nebst Bemerkungen über andere Wasserpilze. *Acta Horti Bot. Univ. Latviensis* 4: 201-241.
- Barnes, B. & R. Melville.** 1932. Notes on British aquatic fungi. *Trans. British Myc. Soc.* 17: 82-96.
- Blackwell, E.** 1937. Germination of resistant spores of *Blastocladiella Pringsheimii*. *Nature* 140: 933.
- Butler, E. J.** 1907. An account of the genus *Pythium* and some Chytridiaceae. *Mem. Dept. Agr. India* 1st: 1-160.
- . 1911. On *Allomyces*, a new aquatic fungus. *Ann. Bot.* 25: 1023-1034.
- Coker, W. C.** 1923. The Saprolegniaceae, with notes on other water molds. 201 pp., Univ. of N. C. Press, Chapel Hill.
- . 1927. Other water molds from the soil. *Jour. Elisha Mitchell Sci. Soc.* 42: 207-226.
- & **H. H. Braxton.** 1926. New water molds from the soil. *Jour. Elisha Mitchell Sci. Soc.* 42: 139-149.

- Cook, W. R. I. & E. Morgan. 1934. Some observations on the Saprolegniaceae of the soils of Wales. Jour. Bot. 72: 345-349.
- Cookson, I. 1937. On *Saprolegnia terrestris* sp. nov. with some preliminary observations on Victorian soil Saprolegniales. Proc. Royal Soc. Victoria 49: 235-243.
- Couch, J. N. 1927. Some new water fungi from the soil, with observations on spore formation. Jour. Elisha Mitchell Sci. Soc. 42: 227-242.
- Dissmann, E. 1931. Zur Kenntnis einer neuen Isoachlya-Art aus dem Erdboden. Beih. Bot. Centralbl., II Abt. 48: 103-111.
- Emerson, Ralph. 1937. Experimental studies of sexuality, heredity, and alternation of generations in *Allomyces*. 117 pp., Ph.D. Thesis, Harvard University (unpublished).
- . 1938. A new life cycle involving cyst-formation in *Allomyces*. Mycologia 30: 120-132.
- Harvey, J. V. 1925. A study of the water molds and Pythiums occurring in the soils of Chapel Hill. Jour. Elisha Mitchell Sci. Soc. 41: 151-164.
- . 1927. *Brevilegnia diclina* n. sp. Jour. Elisha Mitchell Sci. Soc. 42: 243-246.
- . 1928. A survey of the water molds occurring in the soils of Wisconsin as studied during the summer of 1926. Trans. Wis. Acad. 23: 551-562.
- . 1930. A taxonomic and morphological study of some members of the Saprolegniaceae. Jour. Elisha Mitchell Sci. Soc. 45: 319-332.
- Hatch, W. R. 1933. Sexuality of *Allomyces arbuscula* Butler. Jour. Elisha Mitchell Sci. Soc. 49: 163-170.
- . 1935. Gametogenesis in *Allomyces arbuscula*. Ann. Bot. 49: 623-649.
- Höhnk, W. 1935. Saprolegniales und Monoblepharidales aus der Umgebung Bremens, mit besonderer Berücksichtigung der Oekologie der Saprolegniaceae. Abh. Naturf. Ver. Bremen 29: 207-237.
- Kniep, H. 1929. *Allomyces javanicus*, n. sp., ein anisogamer Phycomycet mit Planogameten. Ber. Deuts. Bot. Ges. 47: 199-212.
- . 1930. Über die Generationswechsel von *Allomyces*. Zeitschr. Bot. 22: 433-441.
- Morgan, E. 1938. The phycomycete flora of Glamorgan; the Saprolegniales, especially the terrestrial forms. Jour. British A. A. S. 1938: 109-110.
- Nagai, M. 1931. Studies on the Japanese Saprolegniaceae. Jour. Fac. Agr. Hokkaido Imp. Univ., Sapporo 32: 1-43.
- Raper, K. B. 1928. Studies on the frequency of water molds in the soil. Jour. Elisha Mitchell Sci. Soc. 44: 133-140.
- Richter, W. 1937. Vorarbeiten zu einer Saprolegniaceenflora von Marburg. Flora, N. F. 31: 227-262.
- Zopf, W. 1888. Zur Kenntnis der Infections-Krankheiten niederer Thiere und Pflanzen. Nova Acta Leop.-Carol Deutsch. Akad. Naturf. 52: 313-376.

FIVE NEW ZOOPAGACEAE DESTRUCTIVE TO RHIZOPODS AND NEMATODES

CHARLES DRECHSLER

(WITH 5 FIGURES)

Five fungi referable to the Zoopagaceae are herein described as new, increasing the number of species presented as members of that family to thirty-eight. A sexual stage has so far been observed in only one of the five forms. As the form in question appears most closely allied to *Stylopaga araea* Drechsl. (4) occasion is taken to submit also a brief account dealing with the sexual stage of the latter species, supplementing the earlier characterization based on its vegetative and asexual reproductive phases. Among the new fungi not known to produce zygospores is included a species that in adaptation to an endoparasitic development within nematodes, gives rise to conidial apparatus which differs markedly from any hitherto represented in the group and thus makes necessary the erection of a new genus.

STYLOPAGE SCOLIOSPORA

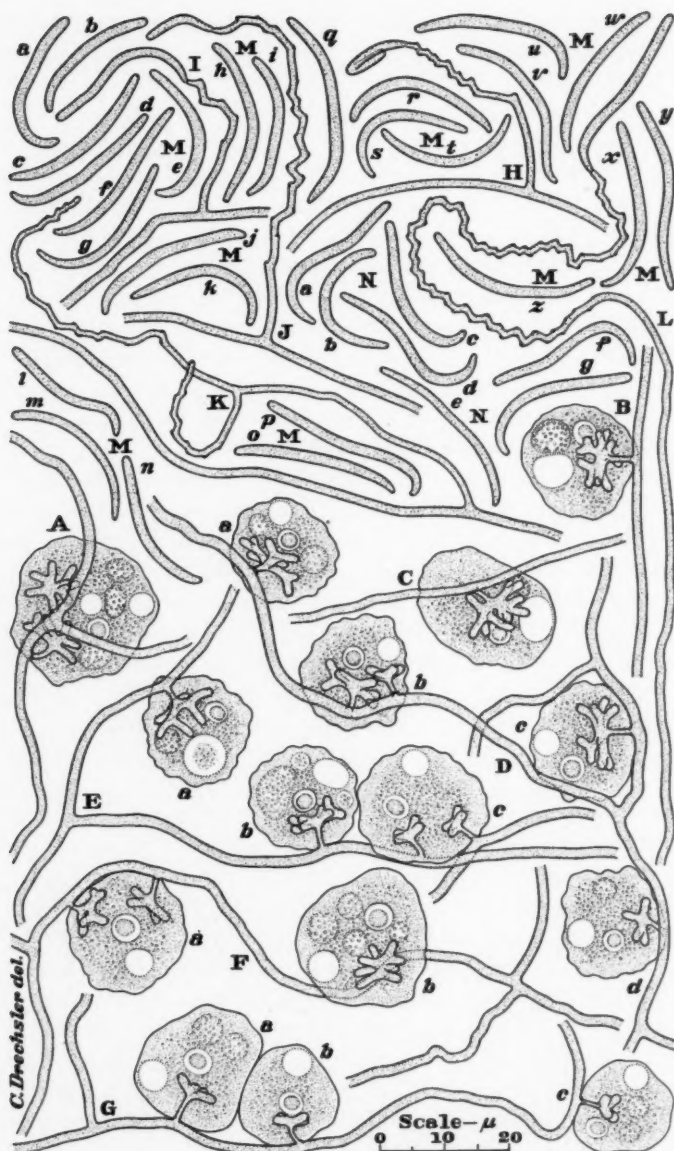
Watersoaked portions of submerged leaves and stems of water cress, *Radicula Nasturtium-aquaticum* (L.) Britten & Rendle, collected on May 13, 1938, from an extensive bed of declining productiveness near Woodstock, Va., gave rise, after being excised and planted on maize meal agar in Petri dishes, to mycelia of several species of *Pythium*. The mycelia in many of the isolation cultures soon became copiously overgrown with bacteria and infested with rhizopods in immense numbers. Later, some of the protozoan forms in the thriving microfauna, including a few that had appeared especially successful in establishing themselves, were virtually if not wholly exterminated through the activity of various members of the Zoopagaceae.

Perhaps not any of the ill-fated animals were more consistently visited by disaster than was an *Amoeba* measuring mostly from 13

to $22\ \mu$ in diameter when drawn into its usual somewhat rounded shape, with contours curving sinuously about numerous delicate pseudopodial protrusions. Despite the small dimensions of the rhizopod, its enveloping pellicle was clearly visible in normal specimens, and persisted in recognizable condition for some time after removal of the protoplasm. In the slightly murky, dispersedly granular sarcode was imbedded a globose or somewhat ellipsoidal nucleus, mostly 3 to $4.5\ \mu$ in diameter, inside the clear outer layer of which was regularly discernible a slightly darker roundish central part, or "Binnenkörper," 1.8 to $2.8\ \mu$ in diameter. A contractile vacuole and a small number of less conspicuous vacuoles, possibly digestive in function, provided additional though less distinctive structural features.

The *Amoeba* in question was captured through adhesion to the hyphae of a delicate aseptate branching mycelium (FIG. 1, A; B; C; D, a-d; E, a-c; F, a, b; G, a-c). Contact of little extent sufficed usually for the intrusion of a haustorium from the hypha into the animal (FIG. 1, B; C; D, a, c, d; E, a, b; F, b; G, a-c); somewhat lengthier contact permitting intrusion of two haustoria (FIG. 1, A; D, b; E, c; F, a). Whether single or plural, the absorptive organ was of the pedicellate type, consisting of narrow stalk and thickish dichotomously branched assimilative elements, exemplified in various species described earlier, as, for example, *Stylopaga rhabdospora* Drechsl. (7) and *S. cephalote* Drechsl. (10). After serving in the appropriation of all protoplasmic materials within the rhizopod, the haustorium was itself evacuated by the withdrawal of contents into the parent filament, its empty envelope thereupon becoming wholly invisible.

Asexual reproduction of the fungus took place abundantly through the development of conidia terminally, either on relatively short branches (FIG. 1, H-K), or sometimes on longer filaments (FIG. 1, L). Following the abscission of one spore, the sporophoric axis continued growth, usually somewhat obliquely, to give rise a short distance farther on to a second, the place of attachment of the first conidium being marked by a perceptible or often a pronounced geniculation. Repetition of the process, a familiar one in many groups of fungi, and already reported in several species of *Stylopaga*, here resulted often in extraordinarily prolonged

FIG. 1. *Stylopage scoliospora*.

fertile elements, showing from 50 to 75 slightly scarred geniculations, from each of which a conidium had been disarticulated. In the agar plate cultures studied, the conidiophorous branches were always found developing in prostrate positions on the surface of the substratum, never in erect positions. Though the possibility is not to be ignored that the recumbent posture may have been due to jostling by numerous nematodes, the obvious frailness of the sporiferous elements would seem in itself to have precluded an erect habit. As the material from which the fungus grew out was of aquatic origin, it seems reasonable to presume that in nature the frail elements are normally submerged. Their homology with the erect aerial conidiophores of terrestrial forms seems, however, sufficiently clear to permit assignment of the fungus to the genus *Stylopage*.

While the conidiophorous branches as a rule were perceptibly narrower than the predaceous filaments, the conidia borne on them approximated the vegetative hyphae in width; so that when strewn about on the substratum they presented an appearance as if they consisted of disarticulated mycelial segments (FIG. 1, *M*, *a-s*; *N*, *a-g*). Regarding such misleading appearance they invite comparison more particularly with the conidia of *Zoopage nematospora* Drechsl. (7), and as in that species the deceptive effect is heightened by the random curvatures that persist after disarticulation. Indeed, a term compounded of words meaning "crooked" and "seed," respectively, suggests itself as a fairly appropriate name for the fungus.

***Stylopage scoliospora* sp. nov.**

Mycelium sparsum, ramosum; hyphis hyalinis, aliquantum irregulariter flexuosis, 1-2 μ crassis, ad animalcula inhaerentibus, pelliculam eorum perforantibus, haustoria singula vel subinde bina in ea introtrudentibus quae carnem exhauriunt; haustoriis pedicellatis, pedicello saepius 1-4 μ longo, 0.6-0.9 μ crasso, abrupte latescente, apice vulgo semel vel ter repetite bifurco, ita 2-8 rarius 10 ramos divaricatos 1-6 μ longos, 1-1.5 μ crassos ferente. Hyphae fertiles procumbentes, foris probabiliter in aqua immersae, modo 10-100 μ sed quandoque usque ad 500 μ longae, 0.8-1.6 μ crassae, ex apice conidium ferentes, deinde identidem repullulantset multa alia (subinde 50-75) conidia deinceps gerentes, ita mox crebre geniculatae; conidiis hyalinis, filiformibus, 20-32 μ longis, 1.3-1.9 μ crassis, saepius plus minusve curvatis.

Amoebas vulgo 13-22 μ latas capiens consumensque habitat in foliis caulibusque languidis *Radiculae Nasturtii-aquatici* prope Woodstock, Virginia.

Mycelium sparse, branching; vegetative hyphae colorless, somewhat irregularly flexuous, 1 to 2μ (mostly about 1.5μ) wide, adhering to minute rhizopods, perforating the integument of each captive, and developing 1 or 2 haustoria inside to appropriate the fleshy contents; haustoria pedicellate, the pedicel often 1 to 4μ long and 0.6 to 0.9μ thick, abruptly widening and successively bifurcating at wide angles 1 to 3 times to terminate in 2 to 8 or more rarely in as many as 10 branches, 1 to 6μ long and 1 to 1.5μ wide. Conidiophorous hyphae prostrate, under natural conditions probably submerge, often 10 to 100μ and sometimes up to 500μ long, 0.8 to 1.6μ wide, after producing a conidium singly at its tip often repeatedly elongating from below the spore to give rise successively to many (sometimes 50 or 75) more conidia, whose places of origin after their disarticulation remain marked by geniculations mostly between 1.5 to 5μ apart. Conidia hyaline, filiform, 20 to 32μ (average 26μ) long, 1.3 to 1.9μ (average 1.6μ) wide, often more or less irregularly curved.

Capturing and consuming a species of *Amoeba* commonly 13 to 22μ in length and width, it occurs in moribund leaves and stems of *Radicula Nasturtium-aquaticum* near Woodstock, Va.

The apparent adaptation of the fungus to an aquatic existence, submerged or floating, would seem to strengthen the likelihood discussed in an earlier paper (3: p. 33-34), that the filamentous outgrowths noted by Leidy (13) on *Ouramoeba vorax* Leidy and *O. botulicauda* Leidy, by Korotneff (12) on *Longicauda amoebina* Kor., by Penard (14) on *Amoeba nobilis* Pen. and *A. vespertilio* Pen., as well as by Dangeard (1) on *Pelomyxa vorax* Dang., may prove to be referable to the Zoopagaceae. Geitler (11), in a recent and somewhat more detailed paper on the morphology and development of similar appendages found attached to *Amoeba proteus* Leidy, concluded that the fungus with which he was dealing unquestionably belonged in the Phycomycetes; though holding further that its position within that class, despite some similarities in outward habit to the Leptomitaceae, was presumptively in the Chytridiales, or more precisely, in the family Cladochytriaceae. An inspection of Geitler's figures, however, would seem to reveal not only a suggestive resemblance between the haustoria of his fungus and the haustoria more particularly of *Zoopage phanera* Drechs. (3), but also an even more provoking similarity between the repeatedly constricted filaments shown attached to *A. proteus*,

on the one hand and immature or growing conidial filaments of *Zoopage atractospora* Drechsl. (7) on the other. If Geitler's illustrations pertaining to the development of resting spores show little evidence of hyphal conjugation, the relationship of parts in one of them (11: fig. 3, r) yet invites comparison with immature sexual apparatus of *Z. cladosperma* Drechsl. (5).

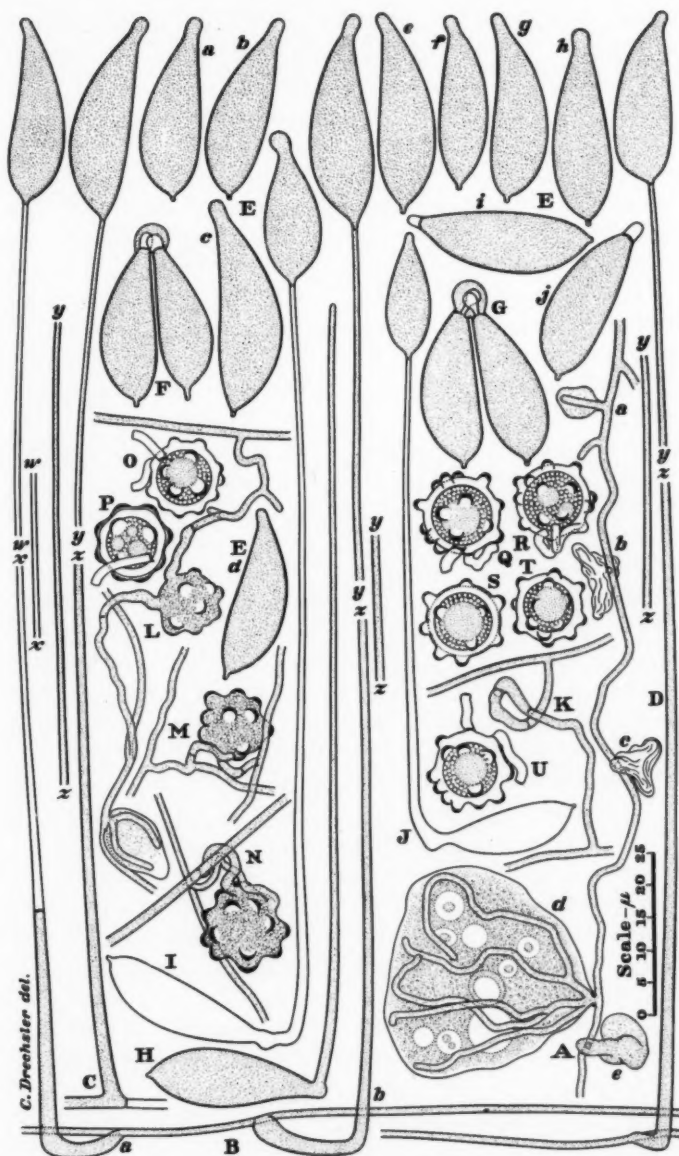
It must be admitted, of course, that the consistently aseptate condition imputed to the filamentous outgrowths by Geitler, as also by earlier writers, and the absence of any massive vegetative part comparable either to the spiral hyphae in the endoparasitic genera *Endocochlus* and *Cochlonema*, or to the greatly swollen conidia of the ectoparasitic genus *Bdellospora*, provide objections to a ready affiliation with the Zoopagaceae; yet these objections may perhaps be subject to abatement when they are considered in relation to the less exigent conditions attending development of *Amoeba* parasites in an aquatic as contrasted with a terrestrial environment. The spiral or globose vegetative thalli familiar in terricolous conidial parasites seemingly have as their special function the accumulation of protoplasmic masses in sturdy, compact bodies, little subject to injury from physical violence during the protracted period when the host remains capable of energetic locomotion. Delicate sporiferous filaments thrust out from an *Amoeba* briskly moving about among solid particles of harsh texture could hardly avoid suffering severe injury, if, indeed, they escaped being shorn off outright, perhaps at a relatively early stage. In a substratum of soil or decaying vegetable detritus, development of such filaments must accordingly be postponed until the animal has been disabled as a result of protoplasmic depletion brought on by the parasite itself. In a water medium, however, the danger from physical injury manifestly is so insignificant that external filaments can be produced from the beginning with complete safety; wherefore the need of rather massive storage structures in the form of obese vegetative thalli is wholly obviated. There is reason to presume, moreover, that while the slight disturbances usual in a water medium may be insufficient to injure a continuous filament destined for conversion into a conidial chain, they might readily suffice to bring about disarticulation of all conidia very soon after they became delimited by the deposition of septa at the constrictions;

in which event intercalary cross-walls would not often be encountered in the portions of filaments left attached, and their normal development in the filaments might therefore long remain unsuspected. As *Stylopage scoliospora* is a predacious mycelial form rather than an infective or parasitic one, and as it produces conidia separately rather than in chains, its usefulness in helping to interpret the problematical outgrowths reported by protozoölogists is less than might be desired.

STYLOPAGE RHYNCHOSPORA

A fungus with a reproductive habit most similar to that of *Stylopage araea* was observed in an old maize meal agar plate culture, which, after having been occupied by mycelium of *Pythium ultimum* Trow, had received the addition of some pinches of decaying vegetable rubbish collected on October 24, 1936, from a roadside ditch in Arlington, Va. On the hyphae making up its sparse mycelium Amoebae varying considerably in size were found attached (FIG. 2, A, a-e; L), some measuring as little in width as $5\ \mu$ (FIG. 2, A, a), others as much as $30\ \mu$ (FIG. 2, A, d). The contents of the smallest animals were assimilated by means of a simple haustorial branch, while expropriation of the larger specimens was accomplished through branched bush-like haustoria of the type represented in *S. araea* and *Zoopage mitospora* Drechsl. (10). With the depletion of protoplasm in each captured rhizopod, the haustorium was itself soon evacuated by withdrawal of its contents into the parent filament, leaving only the collapsed pellicle to supply visible evidence on the fate of the animal (FIG. 2, A, b, c).

As has been intimated, the conidiophores of the fungus, which were found sparsely distributed over the substratum, resemble the fertile hyphae of *Stylopage araea* in general stature; but whereas the latter arise abruptly from the parent mycelial filaments as narrow, only slightly tapering, erect stalks, the former branch off as relatively thick, mostly prostrate elements that become erect some distance from their respectively attachments and taper markedly from wide base to narrow apex (FIG. 2, B, a, b; C; D). The sturdier development of the conidiophore would seem required here to support aloft a conidium of noticeably larger dimensions

FIG. 2. *Stylopaga rhynchospora*.

than that of *S. araea*. Apart from its greater size the asexual spore of the present species is distinguished further by having its tip drawn out in a bluntly rounded beak (FIG. 2, *E*, *a-h*) that sometimes is later evacuated of protoplasmic contents and then becomes walled off as an empty appendage (FIG. 2, *E*, *i, j*). Often when two conidia, on falling to the substratum, happen to make apical contact with one another, their beaks are emptied of contents in secreting a mass of yellow adhesive material; so that the spores are, as it were, soldered or cemented together (FIG. 2, *F*, *G*). Whether the curious union thus effected, the like of which has not been seen in any related form, serves any useful purpose remains uncertain.

Repetitional development of conidia by the production of secondary (FIG. 2, *H*, *I*) and apparently even of tertiary (FIG. 2, *J*) conidia on germ sporangiophores is of frequent occurrence in the species. Just as in instances of similar development in the coarser congeneric forms, *Stylopaga hadra* Drechsl. (5) and *S. leiohypha* Drechsl. (6), both destructive to nematodes, each derived spore is appreciably smaller than its parent.

The fungus was observed to produce sexual apparatus in moderate quantity. Conjugating branches invariably arise from separate mycelial hyphae. They unite apically with very little entanglement of parts (FIG. 2, *K*). A cross-wall is laid down in each of the sexual elements at some distance from the union, to delimit the paired gametantia. The young zygosporangium now develops at the union as a globose intercalary body that during its later stages of enlargement becomes boldly sculptured with warty protuberances (FIG. 2, *L-N*). At full maturity there is revealed within the outer sporangial envelope and generally rather intimately fused with it a thick zygospore wall, which surrounds a parietal protoplasmic layer of coarsely granular texture disposed about a central reserve globule of homogeneous consistency (FIG. 2, *O-U*).

A term compounded of two words meaning "snout" and "seed" respectively, is deemed suitable as a specific name for the fungus.

***Stylopaga rhynchospora* sp. nov.**

Mycelium sparsum, ramosum; hyphis hyalinis, flexuosis, plerumque 1-1.8 μ crassis, ad animalcula inhaerentibus, pelliculam eorum perforantibus, haus-

torium laxe arbusculiforme intus evolventibus quod protoplasma exhaurit. Hyphae fertiles incoloratae, ad summam erectae etsi in parte infera saepius procumbentes, 170–220 μ longae, basi 2–3.5 μ crassae, sursum attenuatae, apice 0.7–0.8 μ crassae, unicum conidium ferentes. Conidia hyalina, elongato-ovoidea, basi pediculo 1–2 μ longo circa 0.8 μ crasso praedita, apice rostro rotundato 2–3.5 μ longo 1.6–2.8 μ crasso subinde vacuo instructa, ex toto vulgo 27–34 μ longa, 7.5–10 μ crassa, saepius ex hypha fertile germinationis circa 120 μ alta conidium ordinis secundi modo 24–28 μ longum, 7.5–9 μ crassum proferentia; conidiis ordinis secundi ex hypha fertile germinationis 75 μ alta conidium ordinis tertii circa 19 μ longum 6.5 μ crassum subinde item proferentibus. Hyphae zygosporiferae 10–35 μ longae, 1–1.5 μ crassae, septo saepius 6–10 μ ab junctioe divisae, utraque ex alia hypha mycelii enata. Zygosporangia sphaeroidea, vulgo 10–12 μ crassa, maturitate 12–25 verrucis 0.8–2 μ altis 1.5–3 μ latis ornata, membrana cum membrana zygosporae flavidae quae cellulam viventem 7.5–9 μ crassam circumdat quasi concreta.

Amoebas vulgo 5–30 μ latas capiens consumensque habitat in reliquiis plantarum putrescentibus in Arlington, Virginia.

Mycelium branched, sparse; vegetative hyphae colorless, somewhat flexuous, mostly 1 to 1.8 μ wide, adhering to small rhizopods, perforating the pellicle of each captive and developing within it a bush-like branching haustorium to appropriate the protoplasmic contents. Conidiophores colorless, often procumbent at the base for a distance of 5 to 20 μ , then becoming erect, 170 to 220 μ in total length, mostly 2 to 3.5 μ wide in its proximal portion, tapering upward to a diameter of 0.7 to 0.8 μ at the apex, there bearing a single terminal conidium. Conidia colorless, elongated ovoid, 27 to 34 μ (average 30 μ) in total length, 7.5 to 10 μ (average 8.9 μ) in width, bearing basally a small pedicel usually 0.8 μ wide and 1 μ or rarely up to 2 μ long, distally drawn out into a bluntly rounded beak 2 to 3.5 μ long and 1.6 to 2.8 μ wide that may become evacuated, sometimes with secretion of yellow glutinous material causing cohesion in pairs tip to tip; often giving rise individually on a germ sporangiophore about 120 μ high to a secondary conidium usually 24 to 28 μ long and 7.5 to 9 μ wide; the secondary conidium in turn sometimes giving rise to a tertiary one, mostly about 19 μ long, and 6.5 μ wide, on a germ sporangiophore about 75 μ high. Zygosporic hyphae 10 to 35 μ long and 1 to 1.5 μ wide, those of a conjugating pair arising from separate mycelial filaments, each divided by a septum often placed 6 to 10 μ from the juncture. Zygosporangium intercalary, subspherical, at maturity boldly ornamented with 12 to 25 warty protuberances mostly 0.8 to 2 μ high and 1.5 to 3 μ wide, its wall often rather indistinguishably fused with the thicker wall of the yellowish zygosporangium, which incloses a subspherical protoplast 7.5 to 9 μ in diameter.

Capturing and consuming Amoebae mostly 5 to 30 μ wide, it occurs in decaying remains of herbaceous plants in Arlington, Va.

THE SEXUAL STAGE OF *STYLOPAGE ARAEA*

During the several years that have intervened since it was first described, *Stylopage araea* has been observed from time to time in old plate cultures planted with decaying vegetable materials collected in Virginia and Maryland. Its mycelium and conidial apparatus were associated in some of these later cultures with sexual apparatus distinctive of the species. As in *S. rhynchospora*, and, indeed, in most allied forms whose sexual stage has come under observation, the zygomorphic hyphae destined for conjugation with each other arise as branches, outwardly little differentiated, from separate mycelial filaments. On making contact the two branches wind about one another, each describing approximately two complete turns before apical fusion takes place (FIG. 3, *A*). A septum now is laid down in each of the intertwined branches, most often at a distance of 7 to 15 μ from the union; and the young zygosporangium begins to develop as a globose body, now virtually sessile (FIG. 3, *B*, *D*, *E*), now terminal on a stalk up to 10 μ long that may arise from near the union, or at a distance of 5 to 10 μ from it (FIG. 3, *C*, *F*). When the growing zygosporangium has attained or nearly attained a definitive diameter of 9 to 12 μ , it thrusts out 20 to 35 warty protuberances mostly about 0.7 μ high and 1.5 μ wide. It is then cut off by a basal septum (FIG. 3, *G*, *a*), and a zygosporangium wall is laid down, usually so close to the sporangial envelope that demarcation between the two membranes is little evident (FIG. 3, *G*, *b-j*). Reorganization of the living contents proceeds with gradual enlargement of two or three vacuole-like inclusions (FIG. 3, *G*, *b-e*, *g-i*) that eventually may coalesce into one; so that in its fully mature state the sexual body, always distinctly yellowish in color, incloses a subspherical protoplast 6 to 8.5 μ in diameter, composed of a parietal coarsely granular layer and a central reserve globule (FIG. 3, *G*, *f*).

COCHLONEMA PUMILUM

A fungus rather closely similar morphologically to *Cochlonema cylindricum* Drechsl. (9) appeared in a few old maize-meal-agar plate cultures on which had been planted some pinches of leaf mold collected on April 26, 1937, in deciduous woods in Arlington,

Va. It subsisted exclusively on testaceous rhizopods referable to the genus *Euglypha*, the animals utilized for food being, however, markedly smaller than *E. denticulata*, the species parasitized by *C. cylindricum*, measuring, as they did, only about $11\ \mu$ in thickness, 13 to $19\ \mu$ in width, and 22 to $30\ \mu$ in length (FIG. 3, H-U). The elliptical scales making up the testae measured about $5.5\ \mu$ in length and about $2.5\ \mu$ in width; those bordering the mouth, usually 6 to 8 in number, being modified at the projecting end by very narrow marginal thickening and frequently, too, by some inconspicuous serrulation. A subspherical nucleus about $5\ \mu$ in diameter and containing a globose body about $1.3\ \mu$ wide frequently remained distinguishable during the earlier stages of infection (FIG. 3, H, K). From their morphology the animals, all very obviously conspecific, would seem best referable to *E. levis* (Ehrenb.) Perty as that species is set forth by Wailes (15), though I am inclined to doubt their identity with the rhizopod earlier and perhaps more correctly recorded under that binomial as being captured and consumed by *Dactylella passalopaga* Drechsl. (8). The specimens of *Euglypha* destroyed by the predaceous hyphomycete were uniformly of considerably larger dimensions, and showed generally a somewhat larger number of oral scales which individually appeared more heavily and more extensively thickened at the smooth projecting end. However, a similarity in general outward habit, certainly not shared by *E. denticulata* with its smoothly ovoid shape and very obscurely delimited mouth, would seem to sustain in some degree the application of one binomial to the two forms, encouraged, whether rightly or wrongly, by the broad species concept pervading much protozoölogical literature.

Infection of the small shelled rhizopod results from ingestion usually of a single rod-shaped conidium (FIG. 3, H). This conidium germinates by putting forth from one of its ends, often somewhat obliquely, a delicate germ-tube that soon widens into a thallogenic hypha (FIG. 3, I-M, T, U). In continuing growth the hypha becomes recurved, and thus acquires a strongly arched bail-like shape (FIG. 3, K, L, N, O, R, S), or even a convolute or circinate shape (FIG. 3, I, J, M, P, Q, T), depending on the measure of elongation. Apparently while the animal is still capable of locomotion, the thallus gives off a single reproductive filament from

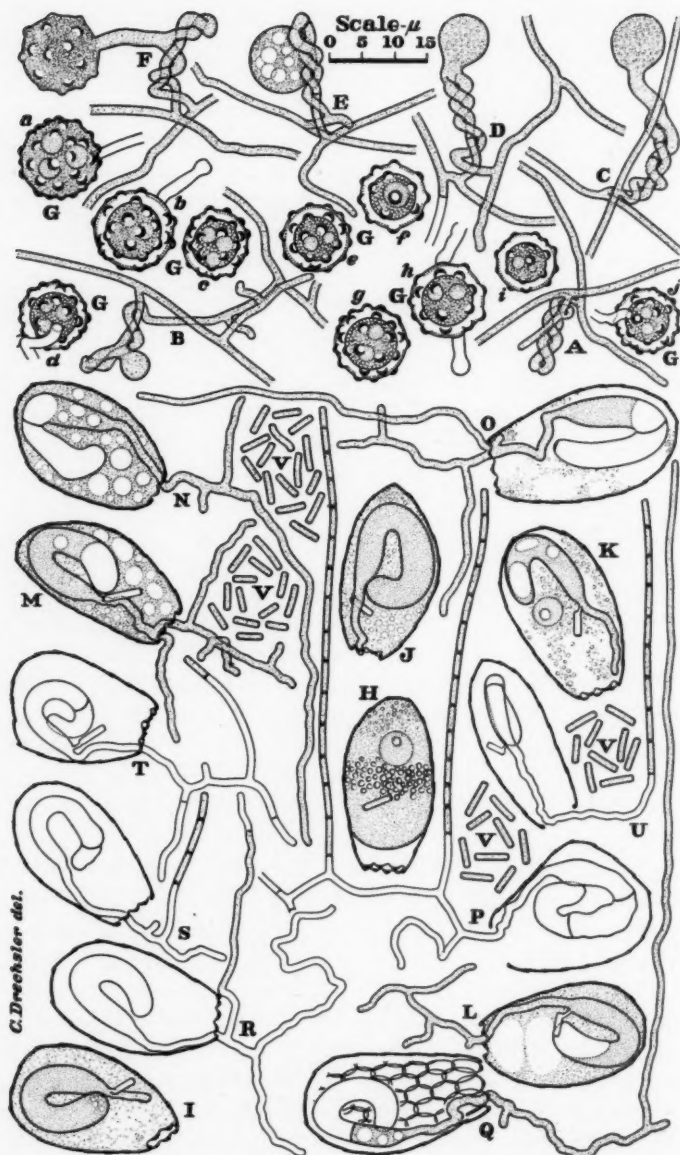


FIG. 3. A-G. *Stylopage araca*; H-V, *Cochlonema pumilum*.

its proximal end, close to the attachment of the empty conidium (FIG. 3, *I-K*). After the animal is disabled this filament grows out through the oral opening, sends a few short branches into the substratum for anchorage (FIG. 3, *L, M*), and gives rise to one, two, or more rarely three aerial hyphae (FIG. 3, *N, O, Q*). These aerial hyphae elongate as protoplasm from the underlying parts of the fungus is transferred to them; but as the amount of nourishment available is always relatively small, their combined lengths ordinarily do not exceed $350\ \mu$ or $400\ \mu$. Segmentation of the aerial hyphae converts them into chains of closely arranged rod-shaped conidia. In these chains the individual conidium is often very narrowly in contact with its neighbors by its slightly convex end-walls (FIG. 3, *P, S, U*). Disintegration of the conidial chains from slight disturbances leaves the spores strewn about on the substratum, ready to infect any specimen of the protozoan host that may unhappily ingest one of them. The somewhat shrunken, empty, curved thallic envelopes remaining inside the empty testae are usually rather inconspicuous (FIG. 3, *R*), but may often be discerned with less difficulty when they contain one or two cross-walls laid down in the course of their evacuation (FIG. 3, *P, S, T, U*).

The fungus, manifestly belonging to the genus *Cochlonema*, is held to be specifically distinct from *C. cylindricum*; the distinction being based more on the smaller dimensions of its conidia than on the dwarfish proportions of its thallus, wherein, to be sure, might merely be reflected the small bulk of the host animal.

***Cochlonema pumilum* sp. nov.**

Hyphae alitae incoloratae, $20-40\ \mu$ longae, $3-5\ \mu$ crassae, simplices, plerumque semel circulatim convolutae, ex basi per os animalis hypham genitabilem $1-1.5\ \mu$ crassam proferentes, quae paucos brevis ramulos in materiam subjacentem intromittit et 1-3 hyphas fertilis erectas vulgo $100-300\ \mu$ longas, $0.9-1.1\ \mu$ crassas in aera emittit. Conidia hyalina, cylindrata, vulgo $3-6\ \mu$ longa, $0.9-1.1\ \mu$ crassa, utrimque leviter rotundata, in catenulas crebre digesta.

Englypham levem forma minore enecans habitat in humo silvestri in Arlington, Virginia.

Vegetative hyphae colorless, 20 to $40\ \mu$ long, 3 to $5\ \mu$ wide, circularly or often circinately convolved in approximately one (0.7 to 1.3) turn, each extending from its base and through the mouth of the host animal a reproductive filament 1 to $1.5\ \mu$ wide, which sends a few short branches into the substratum outside and thrusts into

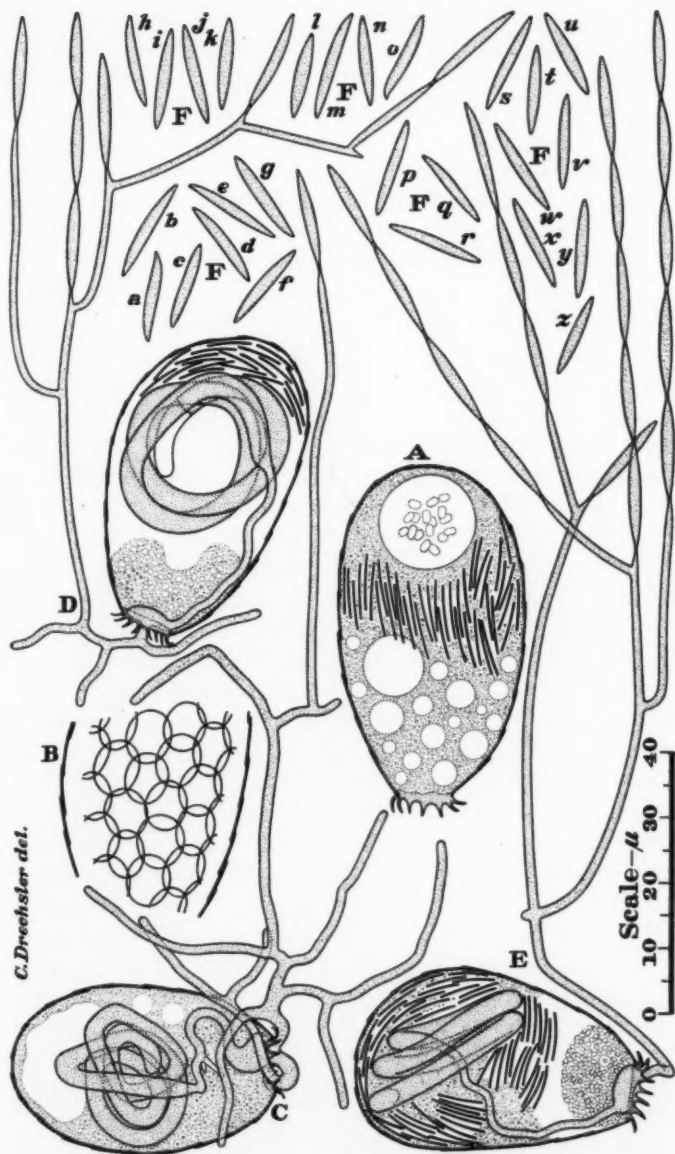
the air 1 to 3 conidiiferous hyphae 100 to 300 μ long, 0.9 to 1.1 μ wide; these hyphae collectively yielding in close catenulate arrangement often about 50 to 75 conidia of cylindrical shape with slightly convexed ends, measuring mostly 3 to 6 μ (average 4.6 μ) in length and 0.9 to 1.1 μ (average 1.05 μ) in width.

Destroying a small form of *Euglypha levis* it occurs in leaf mold in Arlington, Va.

COCHLONEMA FUSISPORUM

Including the fungus just described, three species of *Cochlonema* with rod-shaped conidia comprise all the members of the Zoopagaceae that have so far been set forth as developing endoparasitically in testaceous rhizipods. Several other congeneric forms, also producing rod-shaped conidia and likewise subsisting on testaceous rhizopods have been observed, even if as yet not in sufficient detail to allow an adequate discussion of them. Parasitism on shelled protozoans is, however, not limited to members of the series with cylindrical conidia, being shared unquestionably by a congeneric fungus with spindle-shaped conidia that appeared in an old maize-meal-agar plate culture two months after the addition of some pinches of leaf mold collected on November 22, 1937, in deciduous woods in Arlington, Va.

The fungus in question consistently parasitized an ovoid animal measuring usually 45 to 52 μ in length and 25 to 28 μ in width, which was covered with imbricated broadly elliptical scales often 7 to 8.5 μ long and 6 to 7 μ wide (FIG. 4, A, B). At the circular mouth the testa was fringed with a sharply dentate honey-colored band; near the fundus was contained a large spherical nucleus often 13 to 15 μ in diameter, within which a loose central assemblage of slightly darker oblong parts was discernible. Since the rhizopod thus conforms closely to the description of *Sphenoderia dentata* Pen. as given by Penard (14) and by Wailes (15), it may confidently be referred to that species. Apparently because of a rather dense texture of the animal's protoplasmic contents the thallus of the parasite was very often badly obscured, and consequently for the most part escaped notice until some development of hyphae outside betrayed its presence (FIG. 4, C-E). In specimens of the host containing numerous scales preparatory to divi-

FIG. 4. *Cochlonema fusisporum*.

sion, the fungus could usually be detected earlier through conspicuous displacement of the plates from their normal position in a well ordered equatorial layer (FIG. 4, *D*, *E*).

The thallus appears usually of a bulk scarcely commensurate with the size of the parasitized animal. In the few instances where the vegetative body could be followed with certainty throughout its length, it was found to consist of an unbranched hypha, only moderately swollen, and coiled sometimes irregularly (FIG. 4, *C*), but more often with fair geometrical symmetry (FIG. 4, *D*, *E*), in only two, three, or four simple turns. The relatively small volume of the convolved structure is necessarily associated with comparatively early development of external parts; for only through such earlier development could the thallus be enabled after a brief initial period to function essentially after the manner of a haustorium in transmitting assimilated materials to conidial apparatus outside the host, instead of retaining them to augment its own volume. Now, as development of external parts requires the infected animal to be incapable of further locomotion, it follows that the fungus must somehow bring about early disablement of its host. A probable means by which such a result might be accomplished is to be recognized in a conspicuous gag-like enlargement of the reproductive hypha immediately within the animal's mouth (FIG. 4, *C-E*)—a curious modification not observable in allied forms, and assuredly well placed to interfere with or to disrupt the pseudopodial equipment of the rhizopod.

For the rest, the reproductive filament follows a usual course of development. It arises always singly from the proximal end of the thallus, reaches the oral opening of its host often by a somewhat circuitous path, and after emerging therefrom and in some instances sending a few short branches into the substratum, gives rise to erect or ascending aerial hyphae constricted at regular intervals. Through evacuation of protoplasm from the constrictions, and deposition of end-walls by the separated protoplasts, the aerial hyphae become converted into chains of spindle-shaped conidia, that, except for the absence of all sculpturing, recall the catenulate conidia of *Zoopage tryphera* Drechsl. (9). After the production of one chain of asexual spores, the supporting hypha often grows out somewhat obliquely from a point just below its

sharply tapered apex, to give rise a little farther on to a second conidial chain (FIG. 4, *E*), and frequently, by successive repetition of the process, to additional chains (FIG. 4, *D*). Apart from sub-terminal elongation, some increase in sporiferous hyphae is provided for through lateral branching (FIG. 4, *D*, *E*).

The shape of its conidium suggests for the fungus a name compounded of two words meaning "spindle" and "seed," respectively:

***Cochlonema fusisporum* sp. nov.**

Hyphae alitae incoloratae, circa 150–175 μ longae, 2.2–3.8 μ crassae, simplices, bis vel quater circulatim convolutae, ex basi hypham genitabilem proferentes: hypha genitabili magnam partem 1–1.6 μ crassa sed in ore vel prope os animalis aliquantum inflata, ultra os in ramos fertiles erectos vel ascendentes 1.2–1.6 μ crassos abeunte; conidiis hyalins, levibus, fusiformibus, plerumque 12–17 μ longis, 1.5–2 μ crassis, in catenulas 15–35 sporas assurgentes digestis; ramo fertili deinde tum aliquoties identidem repullulante aliquot additicias cantenulas conidorum deinceps fere gerente.

Sphenoderia dentata enecans habitat in terra silvestri in Arlington, Virginia.

Vegetative hypha colorless, often 150 to 175 μ long, 2.2 to 3.8 μ wide, simple, coiled in 2 to 4 circular turns 15 to 28 μ in diameter, from its proximal end emitting a reproductive filament; the reproductive filament mostly 1 to 1.6 μ wide except for an inflated part at the mouth of the host animal, outside of which orifice it terminates always in erect or ascending conidiiferous branches, besides sometimes giving off one or more short sterile branches into the substratum. Conidia colorless, smooth, spindle-shaped, mostly 12 to 17 μ (average 14.3 μ) long, 1.5 to 2 μ (average 1.76 μ) wide, formed in numbers of 15 to 35 in chains resulting from segmentation of the fertile branches; the basal part bearing a conidial chain often growing out repeatedly from below the pointed sterigmatic tip to give rise successively to additional conidial chains.

Destroying *Sphenoderia dentata* it occurs in leaf mold in Arlington, Va.

In the agar plate culture where *Cochlonema fusisporum* was found subsisting on *Sphenoderia dentata*, the rhizopod at the same time was being captured and consumed by the predaceous hyphomycetous form that I described earlier (2) as *Pedilospora dactylopora*. Perhaps because the phycomycetous parasite rather quickly disables an infected animal, only one specimen of the rhizopod was seen undergoing simultaneous expropriation by both

fungi. Neither of the carnivorous species showed any ill effects from their close positional relationship.

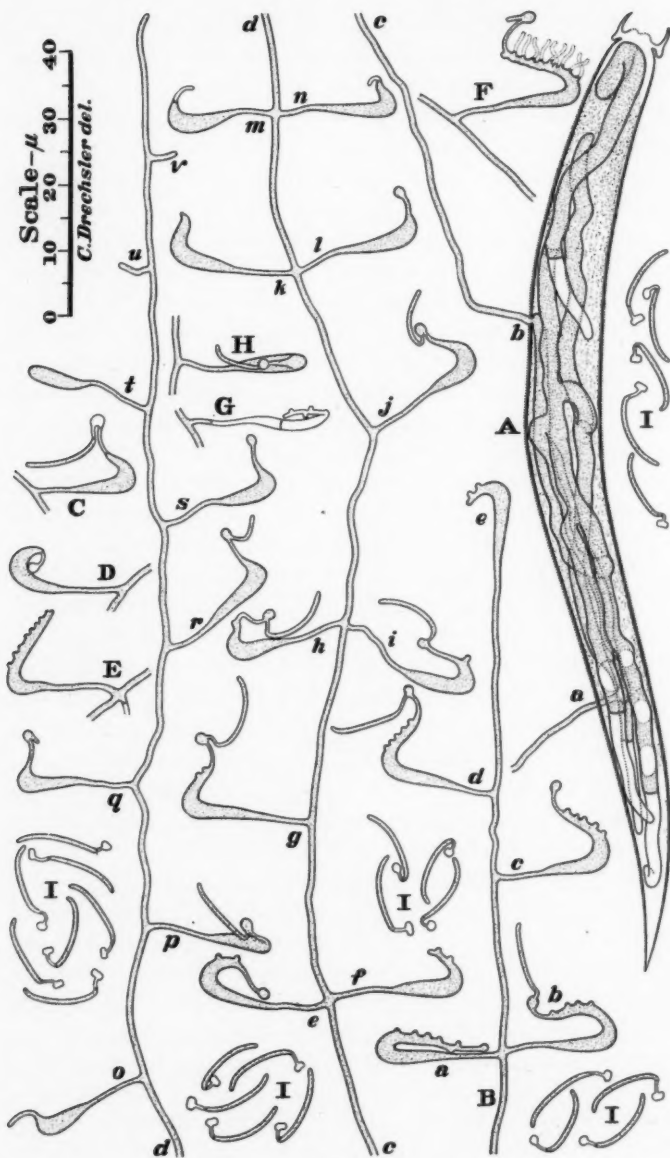
EURYANCALE SACCIOSPORA

Nematodes from their sculpturing obviously referable to a species of *Bunonema* were found being destroyed in considerable numbers on an old maize meal-agar plate culture 4 weeks after it had been planted with some pinches of leaf mold gathered from deciduous woods in Arlington, Va., on March 25, 1938. The distinctive conidial apparatus growing out from the dead animals over the surface of the substratum indicated as the cause of the destruction an endoparasitic fungus comparable in reproductive habit and presumably, too, in biological relationship, to various species of *Harposporium* and *Verticillium* often exterminating large populations of eelworms. Previous to the death of affected nematodes and for some time thereafter, the oily or lumpy degeneration of all fleshy parts largely obscured the organism causing the pathological changes—a difficulty encountered, of course, in virtually all instances where nematodes are invaded by fungi. Later, on advanced depletion of the animal's degenerating contents, the vegetative thallus of the parasite was revealed as a branching filamentous mycelium disposed lengthwise within the sculptured integument, from blunt head to pointed tail. In the earlier observable stages the hyphae were found consistently devoid of septa; so that with respect to structure as well as with respect to dimensions, branching habit and texture of protoplasmic contents, they resembled the haustorial filaments of *Stylopage hadra* and *S. leiophya*. In subsequent stages cross-walls were often present, having manifestly been laid down at intervals as retaining partitions to delimit living portions of hypha from empty portions. Evacuation of the mycelium was found to begin in the outlying elements, the dense finely granular protoplasm being utilized in extending a number of prostrate reproductive filaments over the substratum in various directions (FIG. 5, A).

These filaments originate as delicate branches from the endozoic mycelium, reaching the exterior by narrowly perforating the animal's integument. On attaining a certain length each gives rise some distance back from its tip and usually at an angle approxi-

inating a right angle, to a single prostrate branch (FIG. 5, *A, v, u*), or often to a pair of opposite prostrate branches. For a distance of 5 to 10 μ each branch maintains about the same width as the parent filament; then, however, while extending itself about 10 μ farther, still as a prostrate structure, it widens to a diameter three times greater (FIG. 5, *A, t*). Thereupon it abruptly changes its direction of growth to curve upward and thus to thrust into the air a narrowing beak at the end of which a small but readily noticeable bulbous enlargement is produced (FIG. 5, *A, s*). Sometimes from the adaxial side of this enlargement (FIG. 5, *A, j*), sometimes from its abaxial side (FIG. 5, *A, r*), yet as far as can be determined always approximately in the plane of the upcurved supporting branch, there is put forth a delicate filamentous outgrowth about 15 μ long, often bent rather abruptly about 2 μ from its attachment, and gently curved from the bend to the bluntly rounded tip. A cross-wall is now laid down immediately below the bulbous enlargement; and the enlargement, together with the short adjacent portion of outgrowth up to the abrupt bend, is evacuated by the migration of its protoplasm upward into the longer gently curved distal portion, which thereupon is set off by a retaining septum. Meanwhile the narrow vertical beak-like support below the bulbous enlargement likewise becomes evacuated through withdrawal of its contents back into the stouter portion of the upcurved branch, and a retaining septum is laid down to wall off the empty part (FIG. 5, *C*). When disarticulation then takes place at the partition immediately below the bulbous enlargement, a conidium is released, curiously made up of a slender curved cylindrical living cell together with an empty basal appendage that looks preposterously like a little pouch attached by a longish neck (FIG. 5, *I*).

After one conidium has been produced, the upcurved inflated branch grows out on its adaxial side a short distance below the septum delimiting it from its empty beak, to form a new beak on which after the same elaborate development already described (FIG. 5, *A, h, i*) another conidium is borne. Repetition of the process gives rise successively to a third conidium (FIG. 5, *A, g*), to a fourth, to a fifth (FIG. 5, *B, b*), to a sixth (FIG. 5, *B, d*), and sometimes even to a tenth (FIG. 5, *F*). With each successive elongation the blunt stump of the preceding sterigmatic beak is displaced,

FIG. 5. *Euryancale sacciospora*.

in most instances being pushed into an abaxial position (FIG. 5, *A*, *e-i*; *B*, *b-e*; *E*; *F*). Thus in the end the distal limb of the upcurved inflated branch, which may come to equal (FIG. 5, *B*, *a-d*) or even to exceed (FIG. 5, *E*, *F*) the proximal limb with respect to length, is usually revealed with a series of small dentate protuberances along its upper or abaxial side; the very delicate empty sterigmatic processes borne thereon (FIG. 5, *F*) having become almost indiscernible.

The axial reproductive filament develops after the manner of an indeterminate inflorescence (FIG. 5, *A*). As it continues to elongate it puts forth additional lateral branches at successive intervals, each branch emulating its older fellows in elaborating conidia one by one. Some dozens of sporiferous branches may be produced before axial growth is concluded with the development terminally of a broadened upcurved sporiferous part (FIG. 5, *B*, *e*) homologous with the lateral elements. Owing to the sequence of their formation, the older or proximal branches generally give rise to more conidia than the younger distal ones, though, to be sure, some branches outdistance others below them in productiveness, or, again, are exceeded in productiveness by branches above them. Elaboration of conidia naturally ceases when the vegetative thallus has yielded up all the protoplasmic materials resulting from appropriation of the animal's fleshy contents; the empty lateral branches (FIG. 5, *G*) then soon collapsing, and together with the evacuated envelopes of the other filamentous parts, becoming subject to disintegration.

Presumably the peculiarities of morphology and development embodied in its conidial apparatus, have a part in somehow adapting the fungus for parasitism on its host. The conidia in being formed a short distance above the substratum would seem favorably placed for making contact with the upper side of the habitually creeping animal, where adhesion, or perhaps other physical engagement, is facilitated by pronounced sculpturing of the integument. How the pouch-like conidial appendages may promote infection is more difficult to understand, unless through their flexibility they serve a useful purpose in entangling themselves, possibly with the somewhat rangy cephalic parts of the host, or possibly with its remarkable protuberances.

At all events the parasite manifestly differs so widely from all members of the Zoopagaceae hitherto described, that the erection of an additional genus within that family appears advisable. For this genus a name compounded of words meaning "wide" and "bent arm," respectively, is suggested by the swollen upcurving conidiiferous branches of the fungus; while the peculiar conidial appendages suggest a specific term made up from words meaning "small bag" and "seed," respectively.

Euryancale gen. nov.

Mycelium continuum, ramosum, hyalinum, intra vivens animal crescens, in hyphis filiformibus consistens, post mortem animalis hyphas genitabilis extra evolvens; hyphis genitabilibus continuis, longiusculis, ramulos fertilis identidem emittentibus; ramulis fertilibus continuis, plus minusve incrassatis, ex apice conidia continua hyalina deinceps gerentibus.

Mycelium developing within living animals, continuous, branched, hyaline, composed of filiform hyphae, and giving rise after the death or disablement of the animal, to external reproductive filaments; reproductive filaments continuous, rather long, producing conidiiferous branches one after another; conidiiferous branches continuous, more or less widened, bearing continuous hyaline conidia terminally and often successively.

Euryancale sacciospora sp. nov.

Mycelium in hyphis sterilibus leniter flexuosis plerumque $2-3.5\mu$ crassis consistens, 2-6 hyphas genitabilis emittens; hyphis genitabilibus repentibus, saepius 0.3-1 mm. longis, $0.8-1.2\mu$ crassis, quoque 15-45 ramulos fertilis ad pares angulos singulatim vel bifariam proferente; ramulis fertilibus inter se $10-35\mu$ distantibus, $18-30\mu$ longis, basi filiformibus repentibus $0.7-0.9\mu$ crassis, sursum in aera abrupte recurventibus $2.4-3\mu$ crassis, in sterigma plerumque $3-4\mu$ longum 0.7μ crassum abeuntibus, ex eo unicum conidium gerentibus, deinde tum protoplasmate ex sterigmate identidem subducto in alia sterigmata deinceps recrescentibus et ex eis alia conidia deinceps gerentibus; conidiis hyalinis, in cellula viventi superiore et appendice inani inferiore consistentibus: cellula viventi filiformi, leviter curvata, $11-13\mu$ longa, circa 0.7 crassa; appendice basi ad instar sacculi inflata ibi saepius $1-2\mu$ lata, sursum cervice $1-2\mu$ longa, $0.3-0.4$ crassa adjuncta.

Vermiculos generis *Bumonematis* enecans habitat in humo silvestri in Arlington, Virginia.

Mycelium composed of slightly flexuous hypha mostly 2 to 3.5μ wide, putting forth in various directions from each infected animal usually 2 to 6 creeping reproductive hyphae 0.3 to 1 mm. long and 0.8 to 1.2μ wide; each reproductive hypha giving rise at intervals of 10 to 35μ and at angles approximating a right angle, either singly or oppositely in pairs, to 15 to 45 conidiiferous

branches, which, measuring 18 to 40 μ in total length, consist individually of a prostrate proximal filamentous part, 5 to 10 μ long and 0.7 to 0.9 μ wide, together with a more expanded distal part 2.4 to 3 μ wide that curves abruptly upward into the air to terminate in a tapering sterigma, mostly 3 to 4 μ long and 0.7 μ wide, whereon is produced an apical conidium; the conidiiferous branch after withdrawing the protoplasm from one sterigma, often growing out into a new sterigma to bear another conidium, and then through continued repetition of the process frequently giving rise successively to additional conidia; conidium composed of a continuous, slightly curved, filiform, distal living cell, 11 to 13 μ long and 0.7 μ wide, together with a proximal empty appendage expanded at its base into a pouch-like part, 1 to 2 μ wide, and attached by a slender neck 1 to 2 μ long and 0.3 to 0.4 μ wide.

Destroying nematodes belonging to a species of *Bunonema*, it occurs in leaf mold in Arlington, Va.

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LITERATURE CITED

1. Dangeard, P. A. Études sur le développement et la structure des organismes inférieurs: (I) Les amibes. *Le Botaniste* 11: 4-57. 1910.
2. Drechsler, C. *Pedilospora dactylopage* n. sp., a fungus capturing and consuming testaceous rhizopods. *Jour. Washington Acad. Sci.* 24: 395-402. 1934.
3. —. Some conidial Phycomycetes destructive to terricolous Amoebae. *Mycologia* 27: 6-40. 1935.
4. —. Some non-catenulate conidial Phycomycetes preying on terricolous Amoebae. *Mycologia* 27: 176-205. 1935.
5. —. A new species of conidial phycomycete preying on nematodes. *Mycologia* 27: 206-215. 1935.
6. —. A new species of *Stylopage* preying on nematodes. *Mycologia* 28: 241-246. 1936.
7. —. New conidial Phycomycetes destructive to terricolous Amoebae. *Mycologia* 28: 363-389. 1936.
8. —. A *Fusarium*-like species of *Dactylella* capturing and consuming testaceous rhizopods. *Jour. Washington Acad. Sci.* 26: 397-404. 1936.
9. —. New Zoopagaceae destructive to soil rhizopods. *Mycologia* 29: 229-249. 1937.
10. —. New Zoopagaceae capturing and consuming soil Amoebae. *Mycologia* 30: 137-157. 1938.

11. Geitler, L. Über einen Pilzparasiten auf *Amoeba proteus* und über die polare Organisation des Amöbenkörpers. Biol. Zentralbl. 57: 166-175. 1937.
12. Korotneff, A. Études sur les rhizopodes. Arch. Zool. Exp. Gén. 8: 467-482. 1879-1880.
13. Leidy, J. Freshwater rhizopods of North America. (Rep. U. S. Geol. Surv., vol. 12.) 1879.
14. Penard, E. Faune rhizopodique du bassin de Léman. 1902.
15. Wailes, G. H. *Rhizopoda*, Part III. In Cash, J. & Wailes, C. H. The British freshwater *Rhizopoda*, and *Heliozoa* 3. London, 1915.

EXPLANATION OF FIGURES

FIG. 1. *Stylopage scoliospora*; drawn with the aid of a camera lucida to a uniform magnification; $\times 1000$ throughout. A, portion of a branching superficial hypha from which two haustoria have been intruded into a relatively large specimen of the susceptible *Amoeba*; within the animal are visible also, firstly, the single subspherical nucleus consisting of a light peripheral layer together with a somewhat darker central body, secondly, two conspicuous contractile vacuoles (unstippled), and, thirdly, three digestive vacuoles somewhat obscured by overlying granular material; the three kinds of cellular structures being drawn in a manner uniform for all captured *Amoebae* shown in A-G. B, C, portions of hypha from each of which one haustorium has been intruded into a captured *Amoeba*. D, portion of mycelium with four captured *Amoebae*, a-d; one haustorium having been intruded into each of the three captives, a, c, and d, while two have been intruded into captive b. E, portion of mycelium with three captured *Amoebae*, a-c; one haustorium having been intruded into captive a and into captive b, while two have been intruded into captive c. F, portion of mycelium with two captured *Amoebae*, a and b; two haustoria having grown into the former, and one into the latter. G, portion of mycelium from which a haustorium has been intruded into each of the three captured animals a-c. H, a hypha with a conidiophorous branch showing a young terminal conidium in place, and thirteen geniculations that mark the places of attachment of conidia successively formed. I, portion of hypha whereon is borne a conidiophorous branch showing five geniculations and a fully grown sixth conidium attached terminally. J, portion of hypha with a conidiophorous branch showing a young conidium at its tip, subsequent to the formation earlier of nineteen conidia at successive positions marked by geniculations. K, portion of hypha with a branched conidiophore, the two elements of which show respectively ten and eighteen scarred geniculations, marking places of conidial attachment. L, portion of a long filament with conidiophorous termination showing a fully grown sixty-sixth conidium beyond sixty-five scarred geniculations that mark places of former attachment of successively developed conidia. M, a-z; N, a-g, conidia, showing variations in dimensions and shape.

FIG. 2. *Stylopage rhynchospora*; drawn with the aid of a camera lucida to a uniform magnification; $\times 1000$ throughout. A, portion of mycelial hypha on which five individual *Amoebae*, a-e, are shown attached: one, e, having been captured so recently that penetration has not yet been effected;

two, *a* and *d*, having each been well invaded by a haustorium; the others, *b* and *c*, having each been wholly depleted of contents. *B*, a portion of superficial mycelial filament from which have arisen two conidiophores, *a* and *b*, each bearing a conidium; for want of space the conidiophores are shown in sections—*w* and *x* representing corresponding points on the sections of *a*; *y* and *z* representing corresponding points in the sections of *b*. *C*, a conidiophore bearing a conidium; from want of space shown in sections connecting at the points *y* and *z*. *D*, portion of mycelial hypha with a conidiophore bearing a conidium; from want of space shown in sections connecting at the points *y* and *z*. *E*, *a-j*, conidia, showing variations in size and shape. *F*, two conidia that have become united though cohesion of their glutinous beaks. *G*, two other conidia likewise united through cohesion of their glutinous beaks. *H*, a conidium germinating by the production of a conidiophore. *I*, a conidium that has given rise to a conidiophore whereon is borne fully developed a secondary conidium. *J*, a small conidium, presumably the product of repetitional development, that has in turn given rise to a conidiophore bearing a smaller and presumptively tertiary conidium. *K*, paired zygosporic branches immediately after apical fusion, showing in each one a septum at some distance from the union. *L*, *M*, *N*, three units of sexual apparatus showing successively later stages in enlargement and sculpturing of the zygosporangium; a filament from which one of the sexual branches in *L* is given off, has intruded a somewhat meager haustorium into a small animal captured by it. *O-U*, zygosporangia with zygosporoes in mature condition, illustrating variations in size and sculpturing; attached to them are shown portions of the empty sexual hyphae.

FIG. 3. Drawn with the aid of a camera lucida to a uniform magnification; $\times 1000$ throughout. *A-G*, *Stylopage araea*: *A*, pair of intervolved sexual branches arising from separate hyphae and conjugating by apical fusion. *B*, pair of sexual branches apically united, from which a young zygosporangium has begun to develop laterally at some distance from the union; the septum delimiting one of the gametangia is shown. *C*, sexual apparatus showing the half-grown zygosporangium developing on a stalk arising close to the juncture of the two intervolved sexual branches, in each of which a cross-wall delimits a distal gametangium. *D*, sexual apparatus like the preceding, but with the zygosporangium being developed on a shorter stalk. *E*, sexual apparatus with the zygosporangium sessile at some distance from the union, and nearly fully grown. *F*, sexual apparatus with the zygosporangium terminal on a rather long stalk arising at some distance from the juncture of the sexual branches; attainment of definitive size by the zygosporangium is accompanied by the appearance of warty protuberances. *G*, *a*, zygosporangium after delimitation of a basal septum, but before deposition of a thick oospore wall; *b-j*, zygosporangia containing zygosporoes—the thin warty envelopes of the former being fused rather indistinguishably with the thicker walls of the latter; showing, moreover, variations of the sexual bodies in size, in shape, in organization of contents, and in number and distribution of their warty protuberances. *H-V*, *Cochlonema pumilum*: *H*, partly encysted specimen of *Euglypha levis*, showing the animal's nucleus posterior to the equatorial granular zone, and an ingested conidium of the parasite in an anterior position. *I-K*, specimens of *E. levis*,

each containing a well developed thallus of the parasite; to the proximal end of each thallus is shown attached the empty envelope of the conidium from which it originated, together with the single reproductive hypha growing toward or through the animal's mouth. *L, M*, specimens of *E. levis*, each containing a thallus of the parasite that has given rise to a reproductive hypha, which after growing through the animal's mouth has ramified in the substratum outside; the development entailing evacuation of protoplasm from the distal portion of each thallus. *N, O*, specimens of *E. levis*, each containing a thallus of the parasite, from which has been produced a reproductive filament that after growing through the animal's mouth, has ramified outside to give rise to short sterile submerged elements and to longer aerial hyphae; evacuation of contents from the distal portion of each thallus having led to deposition of an approximately median septum. *P*, depleted testa of a specimen of *E. levis*, and within it the empty envelope of a thallus of the parasite, the protoplasmic contents of which were exhausted in the production of two conidial chains shown only in part from lack of space. *Q*, depleted testa of a specimen of *E. levis*, illustrating the dimensions and arrangement of its scales; within it is shown a thallus of the parasite that in large part has been evacuated of contents in giving rise to the reproductive filament with its lengthy aerial branch. *R-U*, exhausted testae of *E. levis*, each containing a thallus wholly depleted of contents in giving rise to conidial apparatus of which only the proximal parts are shown, owing to lack of space. *V*, conidia showing variations in dimensions and shape. (The testae of all animals in *H-T* are shown flatways; that in *U* is shown edgewise. Though the animals are mainly drawn in approximately median optical view, the oral profile is in most instances also shown, either wholly or partly; and in *Q*, besides, the testa is shown partly in surface view.)

FIG. 4. *Cochlonema fusisporum*; drawn with the aid of a camera lucida to a uniform magnification; $\times 1000$ throughout. *A*, normal full-grown specimen of the host animal, *Sphenoderia dentata*, in a condition shortly preceding reproduction, showing the characteristically dentate oral fringe, the numerous scales for a new individual in the equatorial region, and the large nucleus in a posterior position. *B*, median portion of testa of *S. dentata*, illustrating the size and shape of its component scales, as well as their manner of imbrication. *C*, specimen of *S. dentata* containing a thallus of the parasite convolved in four turns; from its proximal end a reproductive filament has been produced; this filament, after widening markedly at the mouth of the host, resumed its original width on emerging therefrom to ramify outside; one of the resulting branches terminating in a chain of conidia, of which, from lack of space, only the basal member is shown. *D*, a specimen of *S. dentata* whose contents have been largely exhausted, and whose internal scales have been badly dislocated by the rather symmetrically convolved thallus of the parasite lying within, coiled in two and one-half turns; from the proximal end of the thallus has grown the single narrow reproductive filament, that, after swelling into a plug-like expansion at the animal's mouth, resumed its ordinary width on emerging therefrom, and gave rise outside to a few short submerged sterile branches as well as to a long aerial conidiiferous hypha; the latter, after producing a chain of conidia terminally, having grown out repeatedly four times from just below

each successive sterigmatic tip to produce in turn other chains of conidia farther on, exclusive of the one additional chain of spores produced on a lateral branch arising from the main axis some distance below its tip; the most distal of the chains not being shown at all from lack of space, the others being shown only in small part. *E*, specimen of *S. dentata* with protoplasm mostly exhausted and its scales inside badly displaced by a spiral thallus of the parasite consisting of two and one-third turns; from the proximal end of the thallus a single reproductive filament has been produced, which, after swelling into a plug-like distension at the animal's mouth resumed its ordinary width on issuing therefrom into the air, where, with two instances of lateral branching and two of subapical elongation, it gave rise to five chains of conidia, shown only in small part from lack of space. *F*, *a-s*, disarticulated conidia, showing variations in size and shape.

FIG. 5. *Euryancale sacciospora*; drawn with the aid of a camera lucida, to a uniform magnification; $\times 1000$ throughout. *A*, specimen of *Bunonema* sp., permeated internally with a mycelium of the parasite; two reproductive hyphae, *a* and *b*, have been extended over the surface of the substratum—one of them, *b*, being shown from origin to growing tip, in three sections connecting at the points *c* and *d*; along the axial filament *b* are attached lateral conidiiferous branches, *e-v*, in early stages of development near the tip, and becoming progressively older toward the base. *B*, distal portion of a reproductive filament, showing four inflated upcurved lateral conidiiferous branches, *a-d*, on which sterigmatic stumps numbering six, four, five and five, respectively, indicate previous development and disarticulation of like numbers of conidia; the axial filament itself terminates in an expanded upcurved part, *e*, with two sterigmatic stumps on it implying disarticulation of two conidia. *C*, a swollen upcurving conidiiferous branch, with its first conidium shown in mature condition and attached to the empty slender sterigmatic prolongation. *D*, a conidiiferous branch from which its first conidium was detached somewhat abnormally, above rather than below the empty bulb-like part. *E*, a conidiiferous branch showing eight sterigmatic stumps. *F*, a conidiiferous branch supporting nine denuded sterigmata and terminating in a tenth sterigma on which a young conidium is being developed; the empty sterigmata, being only very indistinctly visible, are shown with dotted contours. *G*, an old conidiiferous branch from which the protoplasm has largely been withdrawn. *H*, upper view of conidiiferous branch in normal position, showing attached to it its first conidium still in somewhat immature condition. (Owing to some unavoidable disturbance incident to mounting material under a cover glass, nearly all other upcurved branches are shown as they appear when more or less flattened against the substratum; the unnatural postures, fortunately, revealing to advantage the actual relationship of parts.) *I*, conidia showing variations in size, in shape, and in disposition of the empty pouch-like basal appendages.

OBSERVATIONS ON GASTERELLA LUTOPHILA

JOHN B. ROUTIEN¹

In 1935, Zeller and Walker described a new uniloculate Gasteromycete, *Gasterella lutophila* Zeller & Walker,² which was placed in the Protogastrales.

In order to determine whether or not the fungus was to be found in Michigan, a number of collections of soil were made during the summer and fall of 1938. The soils were collected near East Lansing, Michigan, in two wood-lots of hardwood trees, from a cultivated field, under a willow tree on the campus of Michigan State College, from the bank of the Red Cedar River and from a grove of white pines; there was one collection from the bank of the Wabash River near Montezuma, Indiana.

In each case, soil from the top three inches was placed in a large culture-dish and saturated with sterile, distilled water. After a few hours, the excess water was poured off and the cover of the dish put in place in order to prevent the rapid loss of moisture. The dishes were kept in the dim, natural light of the laboratory; the temperature varied from 80° to 90°, sometimes 94° F. The soils were kept for a period of six weeks.

Any basidiocarps that appeared were collected at various stages of growth, killed, imbedded in paraffin, sectioned and stained.³ After the fruiting-bodies ceased to develop, the soil was stirred slightly, more water was added and then poured off. In one case a few new basidiocarps appeared.

¹ The writer wishes to express appreciation to Dr. E. A. Bessey for his helpful advice and suggestions during the course of this study. He also thanks Dr. Leva B. Walker for her checking of the specimens and her suggestions regarding the nature of the fungus.

² Zeller, S. M. and Leva B. Walker. *Gasterella*, a new uniloculate Gasteromycete. *Mycologia* 27: 573-580. 1935.

³ The killing agent was formol-acetic-alcohol, one of the reagents used by Zeller and Walker. The sections were stained with Heidenhain's iron-alum-haematoxylin; in some cases a counter-stain of light green or bismark brown was used.

Fruiting bodies developed after a period of three weeks on only two of the seven soils collected. Both of these collections were from one wooded area near East Lansing, Michigan. On the basis of this small number of collections, it seems that the fungus is limited to soil in the woods but is not always to be found there.

The specimens from Michigan fitted the description (based on plants from Nebraska) except for a few points. The fruiting-bodies from the former state were $300\text{--}400\ \mu$ in diameter, whereas those from Nebraska were $200\text{--}700\ \mu$ in diameter.

Several small specimens, when carefully removed from the soil, showed the presence of rhizomorphs. A few clamp-connections were visible on these rhizomorphs, but they were never seen on hyphae of the basidiocarp.

The spores of the type specimens were dark, lemon-shaped, verrucose and measured $12\text{--}14 \times 10\text{--}12\ \mu$; these measurements were obtained from permanent slides of the fungus. Of the two collections from Michigan, only one was like the description of *Gasterella lutophila* in regard to spore size, though all specimens showed the spores to be typically citriform and verrucose. In the other collection, the spores of sectioned fruiting-bodies measured $14.5\ (15.8)\text{--}16.2 \times 13.5\ (14.2)\text{--}15.3\ \mu$, and the spores from a living basidiocarp measured $17\ (18.2)\text{--}18.7 \times 12\ (16)\text{--}18.7\ \mu$. Also, pedicels ($1.7\text{--}5 \times 1.7\text{--}2.5\ \mu$) were found on about 15 per cent of the unfixed spores of this same collection.

The nuclear behavior in the basidium seems to be as outlined by Zeller and Walker; that is, the four nuclei formed as a result of meiosis apparently divide once more, and two to four of the resultant nuclei seem to enter the two to four basidiospores.

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THE SYNONYMY OF FOMES FOMENTARIUS

M. T. HILBORN AND DAVID H. LINDER

In connection with some current studies on the biology of *Fomes fomentarius* the senior author had occasion to compile the synonyms of this fungus. In most mycological literature the fungus is cited as *Fomes fomentarius* (L.) Gill., because Gillet published it as such in his *Les Champignons de la France* 1: 686. 1878. Gillet also is usually given credit for having raised Fries' sub-genus *Fomes* to generic rank.¹ However, it was found during the examination of mycological literature at the Farlow Herbarium that Kickx had made the same combination in his *Flore Cryptogamique des Flandres* 2: 237-238. 1867. In his mention of this fungus Kickx refers to Fries' work, "Summa Vegetabilium Scandinaviae, p. 321, 1849" where Fries designated the fungus as *Polyporus (Fomes) fomentarius* (L.). Thus Kickx recognized Fries' sub-genus *Fomes* and used it as a generic name. According to the International Rules of Nomenclature, Section 6, Article 42, this usage makes *Fomes* a valid generic name and the genus becomes *Fomes* (Fries) Kickx. The International Rules also state, in Section 3, that the starting point for nomenclature of this group of fungi, as well as some others, is Fries, *Systema Mycologicum*, 1821-32. Thus the name may be written as *Fomes fomentarius* (Fries) Kickx, or under Recommendation XXXII of this Code, authors earlier than the starting point of the group can be indicated "when useful or desirable" by the use of the word *ex*. Thus the fungus can also be designated as *Fomes fomentarius* (L. ex Fries) Kickx. The synonyms which the writers thus far have found in mycological literature are as follows: Synonymy of *Fomes fomentarius* (Fries) Kickx Fl. Crypt Flandres 2: 237-238. 1867.

¹ Ames, Adeline. A consideration of structure in relation to genera of the Polyporaceae. *Ann. Myc.* 11: 211-253. 1913.

Killermann, S. In Engler-Prantl, *Die Natürlichen Pflanzenfamilien* (2nd ed.) 6: 99-283. 1928.

- Boletus fomentarius* L. Sp. Pl. p. 1176. 1753.
Boletus fomentarius L. Fl. Suecica (2nd ed.) p. 453. 1755.
Boletus unguilatus Bull. Champignons de France p. 357-358. *pl.* 401, 491. 1791.
Boletus fomentarius Pers. (spelled "*fomontarius*") Obs. Myc. 2: 1. 1799.
Boletus unguilatus var. *salicina* Pers. Obs. Myc. 2: 4. 1799.
Boletus unguilatus var. *quercina* Pers. Obs. Myc. 2: 4. 1799.
Boletus igniarius Sowerby, English Fungi 2: *pl.* 132. 1799.
Boletus fomentarius var. *ungulatus* Pers. Synops. Fung. p. 537. 1801.
Boletus fomentarius var. *prunastri* Alb. & Schw. Conspectus Fung. p. 252. 1805.
Boletus fomentarius var. *pomaceus* Alb. & Schw. Conspectus Fung. p. 252. 1805.
Boletus (*Apus*) *fomentarius* Pers. Nees, Syst. Pilze Schwämme. 2: 57. 1817.
Polyporus fomentarius Fries, Syst. Myc. 1: 374. 1821.
Polyporus fomentarius Fries, Epicrisis p. 465. 1836-38.
Polyporus fomentarius var. *excavatus* Berk. Ann. Soc. Nat. History 3: 387. 1839.
Polyporus (*Fomes*) *fomentarius* Fries, Summa Veg. Scand. p. 321. 1849.
Fomes fomentarius (L.) Gill. Champ. Fr. 1: 686. 1878.
Polyporus fomentarius var. *pomaceus* Berk. & Br. Ann. Nat. Hist. V. 12: 373. 1883.
Fomes fomentarius (L.) Fries, Sacc. Syll. Fung. 6: 179-180. 1888.
Ochroporus fomentarius (L.) Schroeter in Cohn, Krypt. Fl. Schlesien 3 (1): 486. 1889.
Elfvigia fomentaria (L.) Murrill, Bull. Torrey Club 30: 298. 1903.
Elfvigiella fomentaria (L.) Murrill, Northern Polypores, Pub. by Author, New York, 64 p. 1914.

In addition to the above named species which are generally accepted as synonyms, Lloyd² would also add, among others, the following: *F. introstuppeus* Cooke, *F. marmoratus* Berk., *F. nigrescens* Klotzsch, *F. sclerodermeus* Lév., and *F. subfomentarius* Romell. While it would be surprising if certain of these species may not with justice be reduced to synonymy along with some other species that may have appeared in the literature, the writers feel it inadvisable to commit themselves on this point until it has been possible to study type specimens.

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² Lloyd, G. C. Synopsis of the genus *Fomes*. Myc. Writ. 4: 211-288. 1915.

AN OVERWINTERING PYCNIDIAL STAGE OF CICINNOBOLUS¹

C. E. YARWOOD

(WITH 1 FIGURE)

The parasitic development of *Cicinnobolus Cesatii* de Bary (syn. *Ampelomyces quisqualis* Cesati) on powdery mildews has been frequently recorded from many regions, and has been well described by Emmons.² Emmons described the entry of *Cicinnobolus* mycelium into sunflower leaves from the parasitized mildew *Erysiphe Cichoracearum* DC. and suggested that a perithecial stage of *Cicinnobolus* was formed in the sunflower leaf, but no adequate description of any overwintering stage has been found by the writer.

On October 15, 1931, at Lafayette, Indiana, the writer placed living clover leaves inoculated October 2 with *Erysiphe Polygoni* DC. and on October 4 with a pure culture of *Cicinnobolus* isolated from clover mildew, in a cheesecloth bag on open ground outdoors. On April 25, 1932, these overwintered leaves were examined. In addition to the old light brown mostly empty pycnidia of *Cicinnobolus* which had formed in the mildew mycelium and conidiophores during the parasitic existence of *Cicinnobolus* the previous season, there were numerous dark brown pycnidia imbedded in the dead leaf tissues. Of 38 single spore isolations of the mature conidia within 2 of these pycnidia, 25 grew and yielded pure cultures of *Cicinnobolus*, typical of cultures isolated direct from the parasitic stage of *Cicinnobolus*. Cultures from the overwintered leaves were parasitic on living clover mildew.

Typical cultures of *Cicinnobolus* were also reisolated from pycnidia formed in mildewed clover leaves inoculated with *Cicinnobolus* and overwintered at Madison, Wisconsin, in the winter of

¹ The assistance of nontechnical employees of the Works Progress Administration is acknowledged.

² Emmons, C. W. *Cicinnobolus Cesatii*, a study in host-parasite relationships. Bull. Torrey Club 57: 421-441. 1930.

1932-33. At Berkeley, California, the saprophytic stage of *Cicinnobolus* was formed by June 6, 1936, on clover leaves which had been inoculated with *Erysiphe* and *Cicinnobolus* on May 1 of the same year, showing that overwintering or the exposure to low temperature was not necessary for the formation of this saprophytic stage.

Similar pycnidia of the saprophytic stage were formed at Berkeley in cucumber leaves inoculated with *Erysiphe Cichor-*

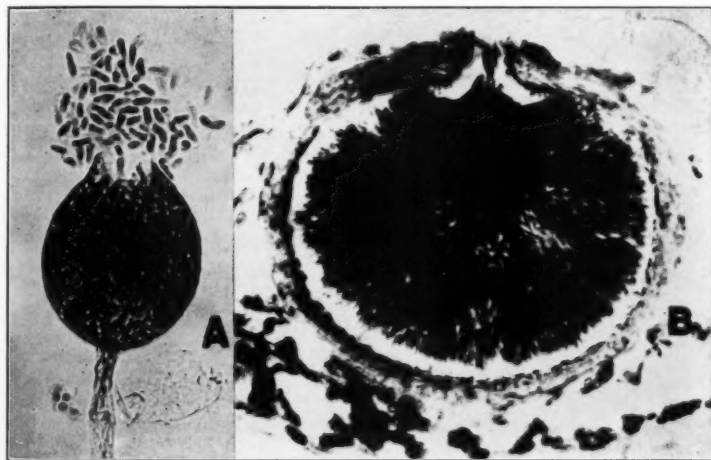


FIG. 1. Pycnidial forms of *Cicinnobolus Cesatii*, both $\times 470$. A, pycnidium formed parasitically within conidiophore of *Erysiphe Polygoni* on living clover leaf; an unparasitized conidium is shown at lower right; B, pycnidium formed saprophytically in dead overwintered clover leaf which had been inoculated, while living, with *Erysiphe Polygoni* and *Cicinnobolus Cesatii*.

accarum from cucumber and *Cicinnobolus Cesatii* from clover powdery mildew.

In the cultures at Madison and Berkeley perithecia of a *Pleospora* developed on the dead leaves containing the saprophytic stage of *Cicinnobolus*, but isolations gave only a *Macrosporium*, though no parasitic *Macrosporium* was known to be present on the inoculated leaves. The *Macrosporium* was somewhat similar to *Macrosporium sarcinaeforme* Cav. but formed fewer spores and

much more mycelium than typical cultures of *Macrosporium sarcinaeforme* isolated by the writer. This fungus is considered to be unrelated to *Cicinnobolus*.

Pycnidia of the parasitic and saprophytic stages of *Cicinnobolus Cesatii* are illustrated in figure 1. Parasitically formed pycnidia are light brown, thin walled, $39-54 \times 18-29 \mu$, discharging spores through an irregular opening at the apex, conidia biguttulate, $3.5-8.4 \times 1.9-4.1 \mu$ (47 measured). Saprophytically formed pycnidia are dark brown, thick walled, spherical, $79-140 \mu$ in diameter, discharging spores through a well formed ostiole, conidia biguttulate, $6.0-11.1 \times 1.8-3.2 \mu$ (90 measured).

SUMMARY

A pycnidial stage of *Cicinnobolus Cesatii* has been found on dead clover and cucumber leaves, previously infected while living with powdery mildew and *Cicinnobolus*, and is apparently responsible for the overwintering of *Cicinnobolus* in nature.

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NOTES ON FLORIDA FUNGI

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(WITH 3 FIGURES)

These notes are based on collections of fungi made by the author and others in various sections of Florida. Extension of the previously published host or geographical range forms the basis of interest in most instances. All of the species referred to are represented in the Herbarium of the Florida Agricultural Experiment Station and the various collections are indicated by the numbers at the end of each note.

1. DIDYMIUM COMPLANATUM (Batsch.) Rost.

Collected 24 July 1935 in Alachua County. Only the one collection has been made in Florida, but apparently it developed from a large plasmodium (*F* 18257).

2. PILOBOLUS UMBONATUS Buller.

This little *Pilobolus* developed abundantly for three seasons on rabbit dung incubated in moist chambers in the laboratory. Pellets collected during the winter in Alachua County, Florida, produced the fungus in almost every case. Pellets from three other widely separated counties (Gadsden, Brevard and Manatee) failed to develop the species. The photograph (FIG. 1) was taken 18 February 1935 and a description drawn up but withheld from publication at that time, thinking that another season's collecting might extend the range. The description corresponds to that published by Dr. Buller in Volume VI of "Researches on Fungi" in every point except the substratum (*F* 18258)

3. ASCOBOLUS VIRIDULUS Phill. & Plow.

This little discomycete has appeared on numerous occasions on the rabbit dung incubated for *Pilobolus*. After about a week in the moist chamber, the small, greenish-yellow cups appear, soon darkening with the ripening of the spores. They promptly be-

come pale again, when the lid of the moist chamber is raised and all the ripe asci have discharged their spores. The measurements of the Florida material differ slightly from those given by Seaver in "The North American Cup-Fungi." Many spores have been found up to $16\ \mu$ long and somewhat over $8.5\ \mu$ wide. However,

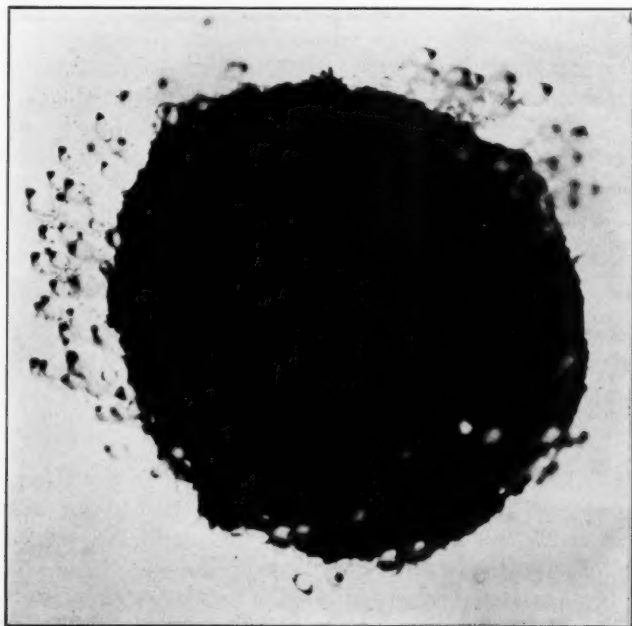


FIG. 1. *Pilobolus umbonatus* Buller.

the spore sculpturing is similar and there are no particular discrepancies in the other characters. One collection has been made under natural conditions on rabbit dung (*F* 3757).

4. *PHILLIPSIA CHARDONIANA* Seaver.

This brilliant discomycete was collected in Alachua County on 28 July 1935 by Geo. F. Weber. This is the first record for the United States, although it has been collected previously in the West Indies (*F* 18256).

5. *GYMNOSPORANGIUM TRANSFORMANS* (Ellis) Kern.

While drying herbarium material collected in Liberty County in 1927 by L. H. Pammel and J. L. Seal, the telial stage of a rust was noted on one lot of *Chamaecyparis thyoides* (L.) B.S.P. Further examination of this material indicated that it was *Gymnosporangium transformans* (Ellis) Kern, a rust previously reported only from the northeastern states, Massachusetts to New Jersey. Since Florida was far out of this range, a specimen was sent to Dr. F. D. Kern, who kindly verified the identification.

Although the alternate host, *Aronia arbutifolia* (L.) Ellis, is common in this section of Florida, the aecial stage has not yet been found (*F* 17532, *F* 17533).

6. *KUEHNEOLA MALVICOLA* (Speg.) Arthur.

The uredinial stage of this rust has been collected several times on *Hibiscus syriacus* L. at Gainesville, Alachua County, and Jacksonville, Duval County (*F* 17085, *F* 5000, *F* 5001).

7. *PHRAGMIDIUM SPECIOSUM* (Fries) Cooke.

This rust has been collected frequently from 1932 to 1938 in Alachua County, Florida, on *Rosa palustris* L. growing on the margins of savannahs. The aecial stage is very conspicuous during the summer, but the telial stage forms inconspicuous felty masses around the twigs late in the fall. This is another common species that somehow has escaped being reported from the South (*F* 17206, *F* 18759).

8. *PROSPODIUM APPENDICULATUM* (Winter) Arthur.

One collection of this rust was made at Miami in Dade County, Florida, on *Tecoma stans* (L.) Juss. on 2 February 1929. It has not been found previously in the United States but it is known from Cuba on this host. Only the uredinial stage has been found in Florida (*F* 17524).

9. *PUCCINIA ANDROPOGONIS XANTHOXYLI* (Peck) Arthur.

The aecial stage of this rust was collected on *Zanthoxylum Clava-Herculis* L. at Gainesville, Alachua County, Florida, on 28 April 1928 and 20 March 1938. There are no known previous records of the rust in Florida (*F* 4773, *F* 17197).

10. PUCCINIA COOPERIAE Long.

What appears to be this rust has been collected a number of times in Florida during the past two years on several species of *Zephyranthes*. It was described by Long¹ from specimens on *Cooperia* in central Texas and Arthur in his "Manual of Rusts" limits it to the same host and region. *Cooperia* is closely related botanically to *Zephyranthes*, but there are no native *Cooperias* known in Florida and but few grown in gardens. In one garden where *Cooperia* and *Zephyranthes* were both grown, only *Zephyranthes* was found infected. Nevertheless, the rust on *Zephyranthes* corresponds morphologically to the species described by Long.

As mentioned by Long for *Cooperia*, all stages of this rust may be present on the same leaf at the same time. Severe infections on the leaves are frequent and in one instance a peduncle (*Z. Treatiae*) was infected.

The teliospores present two interesting and striking characteristics in their attachment and markings. As figured by Long, the spores are frequently bent over so that they seem to be attached at the side. All angles between the normal vertical position and horizontal may be found in the same mount. The peculiar markings on the teliospores consist of several longitudinal ridges, sometimes interrupted and occasionally anastomosing. Their presence gives the spore an angular outline when viewed either from the side or end.

This is the first report of this rust in Florida and in addition to adding a new host genus for the fungus, it greatly extends the geographical range. Two other rusts, both *Aecidium* spp. have been found on *Zephyranthes* sp. in Mexico, but they are quite distinct from *P. Cooperiae*.

Aecio-, uredio- and teliospores from *Z. Treatiae* sown on *Cooperia* (*C. pedunculata* Herb., *C. Drummondii* Herb. and *C. Traubii*) have produced no infection; when sown on *Z. Treatiae*, infection resulted. As morphological characters are lacking, it seems undesirable to designate the rust on *Zephyranthes* as a new form until further inoculations have been made.

Florida collections have been made as follows:

¹ Long, W. H., Jr. Bull. Torrey Club 29: 110. 1902.

On *Zephyranthes Atamasco* (L.) Herb., Jackson County (F 16860).

On *Zephyranthes Treatiae* S. Wats., Alachua County (F 17514, 17511); Putnam Co. (F 16861).

On *Zephyranthes Simpsonii* Chapm., Alachua County (F 17512); Volusia County (F 17513).

On *Zephyranthes* n. sp. (*Z. insularum* Hume in litt.) Alachua County (F 17515).

On *Zephyranthes* n. sp. (*Z. floridana* Hume in litt.) Polk County (F 17510).

One collection has been made on *Zephyranthes Atamasco* at Durham, N. C., communicated by Dr. G. B. Cummins (F 17208).

11. PUCCINIA POLYGONI-AMPHIBII TOVARIAE Arthur.

This form has been collected twice near Gainesville, Alachua County, on *Tovara virginiana* (L.) Adans. It has not been reported previously nearer than Louisiana and North Carolina. Only the uredo stage has been found in Florida (F 17534, F 17535, F 16976).

12. PUCCINIA RAUNKAERII Ferd. & Winge.

Collected on *Rivinia humilis* L. in Brevard County on 25 July 1929 and in Alachua County, Florida, on 25 May 1933. It seems remarkable that a rust causing such conspicuous malformations on a common hammock plant should have escaped observation for so long. The wide distribution of the disease as shown by the divergence of the collections would indicate that the fungus is not a recent immigrant in Florida. Previously reported in the United States from Texas (F 17516, F 17519).

13. RAVENELIA HUMPHREYANA P. Henn.

This rust was collected on *Poinciana pulcherrima* L. in Dade County on 28 March 1928 and again exactly one year later. Only the uredinial stage has been found. There do not seem to be any previous records from the United States, although it has been reported from Cuba, Jamaica, Mexico and Guatemala (F 17525, F 17526, F 17527).

14. *RAVENELIA SILIQUAE* Long.

Specimens of this rust were collected in Alachua County, Florida, 24 March 1934 on the green fruits of *Vachellia farnesiana* (L.) W. & A. Only one plant in a nursery bore infected fruits. Fruit produced in 1935 remained healthy. In the United States this has been reported previously only from southern Texas (*F* 18255).

15. *UREDIO CUMULA* Arthur.

Specimens of this rust were collected in Alachua County on *Buchnera floridana* Gandoger on 10 May 1933 by W. B. Tisdale. Only two diseased plants were found but both were heavily infected. This rust was reported by Arthur in North American Flora as known only from the type locality in Cuba on *Buchnera elongata* Sw., a species very closely related to the Florida host (*F* 17522).

16. *UROMYCES AGNATUS* Arthur.

This rust is common on tread-softly (*Bivonea stimulosa* (Michx.) Raf.) in Florida. The literature shows no record of any pycnial or aecial stage. During May 1938 abundant material of these two stages was collected near Gainesville. Pycnia and aecia are most common on effused galls near the ground line or just below it and are not apparent until the plant is dug up. The galls frequently involve hypertrophied lateral shoots 1 cm. or less long. Occasionally small ones, 5 mm. or less in diameter, occur at the base of petioles, base of leaf blade, on either surface of the leaf blade; more rarely large areas 2-3 cm. long on the underside of the midrib and following out lateral veins a short distance. Various parts of the inflorescence may be involved (FIG. 2, 3). All affected parts bearing aecia are bright yellow.

Most of the plants with aecia also showed uredinia on the underside of the lower leaves at the same time.

Pycnia scattered among the aecia. Aecia amphigenous on bright yellow hypertrophied areas, cupulate, aeciospores globoid $20-23\ \mu \times 22-26\ \mu$; wall colorless $1-2\ \mu$ thick, shallowly verrucose. Collected 10 and 11 May 1938 near Arredonda, Alachua County, Florida (*F* 16718, *F* 16719, *F* 16720).

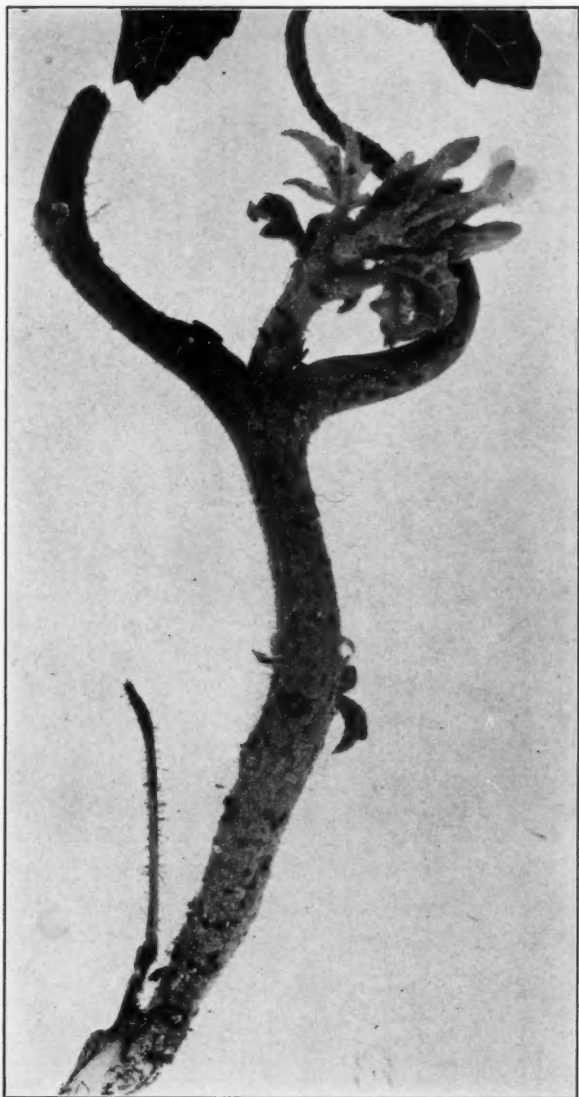


FIG. 2. Pynia and aecia of *Uromyces agnatus* Arthur on stem and inflorescence of *Bivonea*.



FIG. 3. *Uromyces agnatus* Arthur. Aecia on galls on various organs of *Bivonca*. Lower leaf shows uredia on lower surface.

17. *UROMYCES CESTRI* (Mont.) Leo.

One collection was made on *Cestrum diurnum* L. 18 May 1936 also in Broward County, on 25 April 1934. This is the first record of this rust on the mainland of North America. Previous collections have been made in the West Indies, Central and South America on various species of *Cestrum*. On *C. diurnum* it has been reported only from Cuba (F 17517, F 16740).

18. *UROMYCES INDIGOFEAE* D. & H.

Typical material was collected in Alachua County, Florida, on *Indigofera tinctoria* L. on 28 February 1929 and again on 17 November 1935 on *I. suffruticosa* Mill. There does not seem to be any previous record of this rust in the United States (F 17529, F 17530, F 16764).

19. *UROMYCES PUNCTATUS* Schroet.

One collection of this rust was made on *Phaca intonsa* (Sheldon) Rydb. in Alachua County, Florida, on 13 June 1930 and again on 18 March 1935. This collection adds a new host for the fungus and extends its range to the Atlantic Coast (F 16795, F 16796).

20. *UROMYCES SPARGANII* C. & P.

This rust was collected in Sugarfoot Prairie near Gainesville, Alachua County, Florida, on *Sparganium eurycarpum* Engelm. on 10 June 1932. This is a northern species not previously reported south of Ohio (F 17518).

21. *POLYPORUS AMPLECTENS* (Murrill) Sacc. & Trott.

This magnificent little polypore was described by Murrill from specimens on *Asimina* in Georgia. It seems to resemble closely *P. fruticum* Berk & Curt. and Lloyd so referred all his specimens. *P. fruticum*, it has been reported, was described from *Nerium* branches but according to Lloyd *Asimina* was the original host. However, the plant has never been found on *Nerium* in Florida, although infected pawpaw bushes have been found within ten feet of oleanders.

A recent memorandum from Miss E. M. Wakefield at Kew to Dr. W. A. Murrill contains the following information on this point: "Of the three Cuban specimens named by Berkeley *Polyporus fruticum*, only two, nos. 161 and 442, show any trace of the host plant. These appear to be the same, though no. 161 is very fragmentary. No. 442 shows three leaves, elongated obovate in shape, blunt at the apex, coriaceous in texture with rather strongly marked, numerous, parallel lateral nerves. Mr. Sandwith has examined this specimen but is unable to suggest what the plant may be. It is however not *Asimina*."

"The Cuban specimens of the fungus are probably all alike and appear to be the same species as *Inonotus amplexans* Murr. On the same mount as no. 160, however, a Brisbane specimen was stuck by Berkeley. This Brisbane specimen is in my opinion different, and is *Polyporus Weberianus* Henn. It is probable that it is this specimen which has given rise to erroneous ideas as to the identity of *Polyporus fruticum*."

Whatever the status of the species, it is not so rare as indicated by Lloyd and Murrill. In some areas of Florida hardly a pawpaw bush can be found that does not bear one or more of the brown sporophores encircling the branches.

Florida collections include the following hosts:

- On *Asimina parviflora* (Michx.) Duna—Orange Co. (*F* 15520, *F* 15517, *F* 15518), Levy Co. (*F* 15516), Alachua Co. (*F* 8776).
- On *Pityothamnus angustifolius* (A. Gray) Small—Alachua Co. (*F* 8775, *F* 8756, *F* 8777).
- On *P. incanus* (Bartr.) Small (unreported host)—Orange Co. (*F* 15525, *F* 15523), Alachua Co. (*F* 8781).
- On *P. obovatus* (Willd.) Small (unreported host)—St. Johns Co. (*F* 15524).
- On *P. pygmaeus* (Bartr.) Small—Orange Co. (*F* 15522, *F* 15519, *F* 15521).

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THE MORPHOLOGY OF PHYSALACRIA INFLATA

J. M. MCGUIRE

(WITH 14 FIGURES)

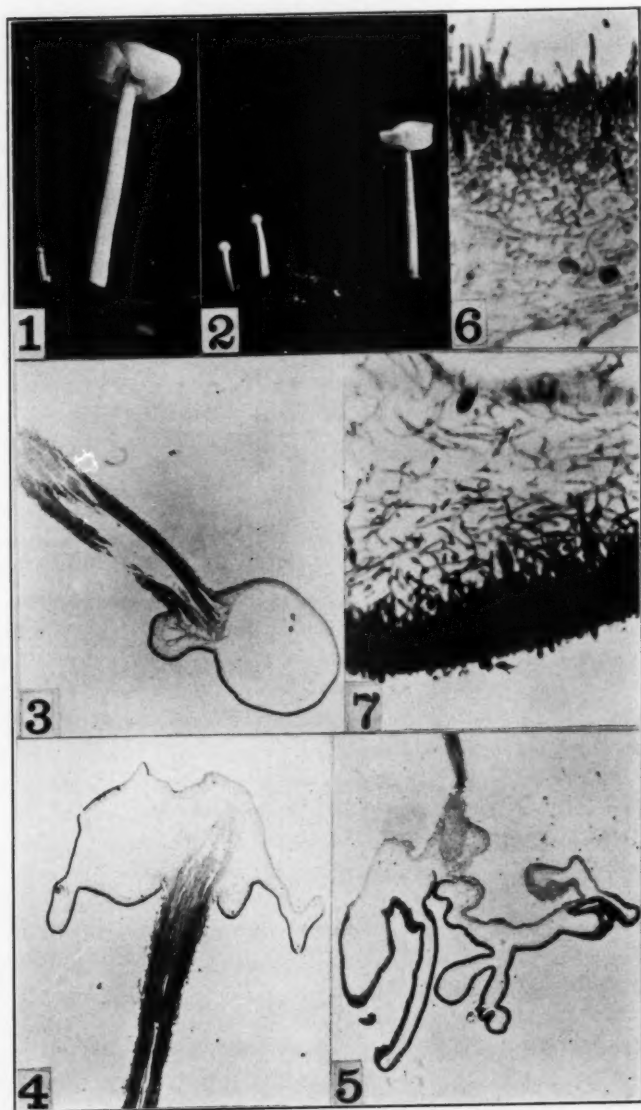
The genus *Physalacria* was established by Peck in 1882 when he showed that the fungus described by Fries as *Mitrula inflata* and later by Cooke as *Spathularia inflata* was actually a Basidiomycete (6). In an excellent description, Peck stated that the surface of the bladder-like head is everywhere covered by the hymenium; and on this basis he included the genus in the family Clavariaceae, where it is generally placed at the present time. He also mentioned that he could find but two sterigmata on the basidia.

Krieger (3), examining fresh specimens, claims to have found several characters at variance with Peck's description. He asserts that the cap is differentiated into distinct upper and lower surfaces, and that the hymenium is borne only on the latter. The upper surface, he finds, shows a looser cell arrangement, with hair-like and encrusted cells scattered about the transition from hymenial to sterile surface. Moreover, the hymenial surface is described as typically thrown into gill-like folds, each ending at the stipe in a decurrent tooth, much as do decurrent gills. The specimens studied by Krieger apparently all grew erect and the hymenium was in the same relative position as it is in a stalked agaric. Because of this restriction of the hymenium to the lower surface and the resemblance of the folds on the lower surface to gills, Krieger proposed to remove the fungus from the Clavariaceae to the Agaricaceae, renaming it *Eoagaricus inflatus*. He states (3, 4) that the stipe is always laterally attached, so that the radiately folded, gill-like hymenium, borne on one side of the stipe, faces downward in the young basidiocarp. As maturity is reached the bladder-like cap is erected by contraction of the tissues of the stipe on one side. The figure illustrating this (4, p. 192) is contradictory, however, in that the folds shown are not radiate and do not appear to terminate at the stipe in decurrent teeth.

Little has been done to clear up the conflict between Peck's original description and Krieger's findings, possibly because the fungus is comparatively rare. Lloyd (5), who collected *Physalacria inflata* several times and received collections also from Burt, believed the hymenium to be amphigenous as described by Peck. Bresadola, to whom Lloyd sent specimens, reported that the basidia bear four sterigmata. Killermann (2), after reading Krieger's paper (3), examined Berlin herbarium material and found the hymenium on all sides. As Coker (1) has remarked, the change of generic name suggested by Krieger is prohibited by the rules of nomenclature.

The present attempt to clarify the morphology of *Physalacria inflata* was made possible by an excellent collection of this fungus on a dead stick in low, wet woods along the Blue River, DeWitt, Nebraska, on June 12, 1938. The stick bore a clump of long-stalked basidiocarps, the stipes confluent at the base. It was brought to Iowa City and placed in a favorable spot in the woods, where two crops of basidiocarps were produced during the summer. On September 12, 1938, the stick was brought into the laboratory and placed in a moist chamber, where several more fructifications have developed and produced spores. Some were fixed in Nawaschin's solution or formalin-acetic-alcohol, imbedded in paraffin, sectioned, and stained in Haidenhain's iron-alum haematoxylin. Others were sectioned freehand or crushed out and examined in weak KOH-phloxine mounts. The rest were dried and placed in the mycological herbarium of the University of Iowa.

Microscopic examination of phloxine-stained fresh mounts disclosed clearly that the hymenium bears typical clavate, four-spored homobasidiomycetous basidia (FIGS. 12, 13). Sections stained in haematoxylin show just as clearly that the surface of the cap is, as Krieger (3) states, differentiated into distinct upper and lower regions, the hymenium being restricted to the lower half. But contrary to Krieger's observations, I find no consistent appearance of gill-like folds radiating from the stipe on the lower surface of the cap. What he apparently did not notice is that the stalks of *Physalacria inflata* do not always stand erect. In fact, very few of the large number of basidiocarps observed in the course of this study grew erect. Many developed directly downward; others



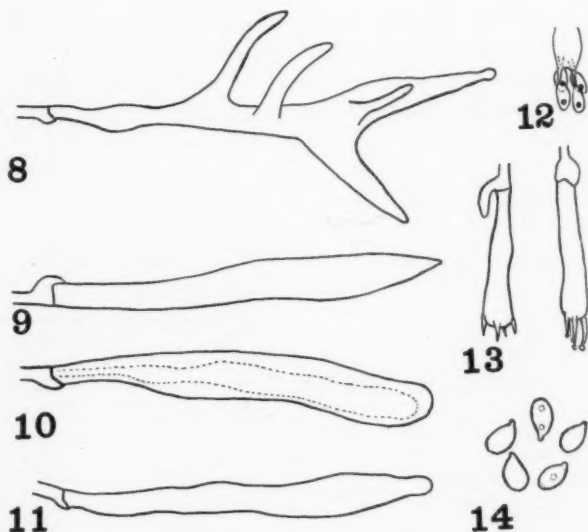
FIGS. 1-7. *Physalacia inflata*.

grew out horizontally or obliquely from the stick to which they were attached. Consequently, the hymenium, which is always borne on the lower portion of the bladder, does not always occur, indeed seldom occurs, in the area immediately surrounding the attachment of the stipe to the pileus, as do the hymenium-bearing gills of the Agaricaceae. Sections of basidiocarps show that whether they grew erect, downward, horizontally, or obliquely, the hymenium invariably occupies the portion of the head which is actually turned downward (FIGS. 3-5). No constant relationship can be seen between the position of the hymenium and the stipe, lobes, folds, or any other irregularities in the surface which might be considered gill-like. In most cases the sterile and the hymenial surfaces were unequal, the latter generally appearing more broadly expanded, rounded, and often invaginated or irregularly lobed, while the upper surface was usually quite smooth and more or less flattened.

New fructifications arise as straight, cylindrical white stalks. Early in the growth of the stalk, a tiny knob appears and gradually expands as the stipe continues to elongate (FIGS. 1, 2). The bladder continues to enlarge for some time after the stipe ceases to elongate, the entire growth period extending over one to two weeks. In all cases observed, the head is nearly globose and centrally attached at the start. It soon takes on the aspect of an inflated bladder, and as it nears maturity may partially collapse. The appearance of lateral attachment of the stipe to the bladder, which Krieger says is universal, was noticed frequently in the later stages of growth. It did not occur in any consistent manner, however, and rather than comprising a fundamental character seems to vary with the position of the basidiocarp and the direction of the light source. The caps seem quite consistently to expand most on the side turned away from the light, although the light at the time of all observations was indirect and diffused. The surfaces of the inflated heads usually remained quite smooth until maturity, when drying resulted in an increasingly wrinkled and lobed appearance. No lobes or folds which by their structure or location might be considered homologous with gills were observed.

Two kinds of cystidia occur on the surface of the head, the one thick, clavate, generally somewhat constricted just back of the broadly rounded tip, usually taking a deep stain with iron-alum

haematoxylin, originating deep within the context and commonly protruding $5\text{--}15\ \mu$ beyond the surface (FIGS. 7, 10, 11), and the other generally more slender, fusoid, often branched, taking almost no iron-alum haematoxylin stain, arising nearer the surface and protruding $20\text{--}40\ \mu$ (FIGS. 6, 8, 9). Both types of cystidia are heavily incrustated. The incrustation is dissolved in 3 per cent KOH mounts, but is little affected by the killing solutions, alcohol, and xylol used in making permanent mounts. Contrary to Krie-



FIGS. 8-14. *Physalacria inflata*.

ger's observation of hair-like and incrustated cystidia scattered about the transition zone between sterile and hymenial portions of the cap, I find cystidia scattered over the entire surface. The two surfaces differ markedly, however, in the types and distribution of cystidia which they bear. The sterile surface bears in great numbers both the thick clavate cystidia and the more slender fusoid, frequently branched cystidia, the latter in much greater numbers (FIG. 6). The cystidia on the hymenial surface are not only much less numerous, but are almost exclusively of the dark-staining clavate type (FIG. 7).

It is my opinion, based on the fact that the hymenium is unilateral and inferior, that *Physalacria inflata* does not belong in the family Clavariaceae, at least as that family is now defined. On the other hand, since gill-like folds, even when present, bear no relationship to the hymenium, and because of other obvious dissimilarities between the inflated, membranaceous basidiocarp of *Physalacria* and those of the gill fungi, I see no justification for placing this fungus in the Agaricaceae. An alternative, since the hymenial elements are clearly those of a homobasidiomycete, might be to include this fungus in the Thelephoraceae, which is characterized by an inferior hymenium.

This study was suggested by Professor G. W. Martin and carried out in the mycological laboratories of the State University of Iowa.

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IOWA CITY

BIBLIOGRAPHY

1. Coker, W. C. The Clavarias of the United States and Canada.
2. Killermann, A. In Engler & Prantl, Die Nat. Pfl. ed. 2 6: 151-152. 1928.
3. Krieger, L. C. C. Preliminary note on the position of the hymenium in *Physalacria inflata* (Schw.) Peck. Maryland Acad. Sci. Bull. 3 (1): 7-8. 1923.
4. —. The mushroom handbook. 1936.
5. Lloyd, C. G. Myc. Writ. 3. Old Species 4. 1908.
6. Peck, C. H. Fungi in wrong genera. Bull. Torrey Club 9: 1-2. 1882.

EXPLANATION OF FIGURES

FIG. 1, three basidiocarps, one mature, two young, $\times 3$; 2, group of basidiocarps, $\times 2$; 3, longitudinal section of basidiocarp in position as developed, showing densely stained hymenial surface below and paler sterile surface above, $\times 12$; 4, section of erect basidiocarp, break in wall marking actual end of hymenium on left side, $\times 12$; 5, section of basidiocarp which grew downward, wrinkled because over-mature when fixed, $\times 12$; 6, section of sterile surface, $\times 300$; 7, section of hymenium, $\times 300$.

FIGS. 8-14 drawn with the aid of camera lucida and reduced in reproduction to a magnification of approximately $\times 1200$. FIG. 8, branched cystidium from sterile surface; 9-11, fusiform and clavate cystidia, incrustation not shown; 12-13, basidia; 14, spores.

THE ENTOMOGENOUS CHYTRID MYROPHAGUS THAXTER¹

F. K. SPARROW, JR.

(WITH 8 FIGURES)

Some years ago the late Prof. Roland Thaxter showed me herbarium material and camera lucida sketches of a peculiar chytridiaceous fungus found by him at Kittery Pt., Me., on dipterous pupae lying in leaf mould. He urged that further search be made for the organism in order to obtain information on certain unknown phases of its life history, as it appeared to represent the type of a new genus. Having been uniformly unsuccessful in this quest I shall record here what is already known about it with the hope that others interested in entomogenous fungi will fill in the lacunae which now exist in its life cycle. I am indebted to Dr. D. H. Linder, Curator of the Farlow Herbarium, for lending me the material and the camera lucida sketches made by Thaxter from which, along with certain notes made in 1927, the following account has been derived.

The only description of this fungus known to me is that of Wize (1) who gave a brief account of the formation of the resting spore and a taxonomic diagnosis under the name *Olpidiopsis ucrainica* Wize. His material was found in larvae of *Cleoni*, *Anisoplia*, in The Ukraine. The organism was described as being fairly rare in its occurrence in that region. Wize noted that the fungus reduced the entire interior of the pupa to an orange colored powdery mass. The earliest stage found was a somewhat spherical cell 35 μ in diameter with granular contents. Later the central region became strongly refractive and golden. Eventually the developing contents became transformed into a double walled resting body which nearly filled the containing structure. This containing

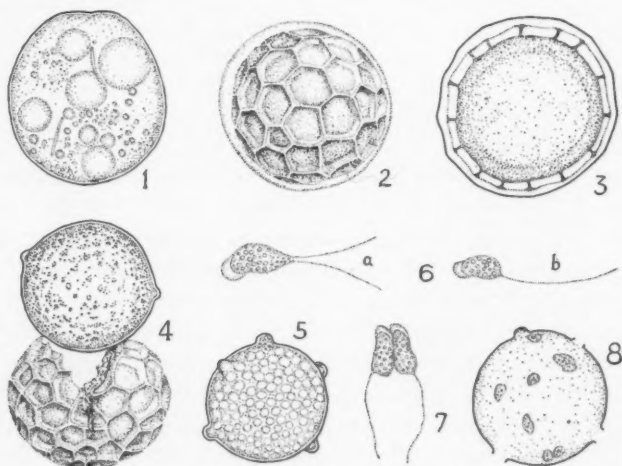
¹ Paper Number 684 from the Botany Department, University of Michigan. The preparation of this paper was assisted by a grant from the Horace H. Rackham School of Graduate Studies.

wall then disappeared leaving free in the cavity of the insect a spherical, golden spore, $20-30\ \mu$ in diameter. The outer wall of the spore was raised in a series of reticulations, and in its content were one ($15-25\ \mu$ in diameter) or many ($5 \times 3\ \mu$) deeply colored globules. No information was given on the vegetative stage other than on the aforementioned sac-like structure within which the resting body was formed. The further fate of this resting spore was not known.

Thaxter's material is similar in appearance to that of Wize. The method of infection and early stages of development are not known. When freshly collected, the contents of diseased pupae are almost completely disintegrated and replaced by a reddish mass of fungous material which as it dries becomes reddish-orange. An examination of this pulverized complex shows it to be made up largely of thousands of beautifully reticulated resting spores (FIGS. 2, 3) each of which lies within a thin-walled sac. These sacs (FIG. 1) are ellipsoidal or very rarely spherical and vary from $55-71\ \mu \times 49-66\ \mu$; the resting spores are spherical and $46\ \mu$ to $72\ \mu$ in diameter. There is no positive evidence of any filamentous vegetative system or of any companion cells. Occasionally, thread-like structures are found attached to the sacs, but these are septate and can be traced to fruiting Imperfecti which have also invaded the pupa. The vast majority show no hyphal or rhizoidal connections of any sort. It should be pointed out however that Thaxter's sketches show several zoöspores which upon germination have formed definite tubular structures. Whether these represent penetration tubes or the beginnings of a filamentous vegetative stage can only be decided by new observations on living, young material. Thus it can be seen that, while the American material is somewhat larger, in all probability Wize and Thaxter were dealing with the same organism.

Thaxter secured germination of the resting spores. This occurred after they had been kept outside all winter until April in moist Sphagnum and earth. Such spores when placed in hanging drop cultures in distilled water cracked open and there was extruded a spherical vesicular body $50-86\ \mu$ in diameter (FIG. 4). Discharge was a continuous process and took about two hours for

completion. The new structure thus formed was nearly or completely free from the wall of resting spore (FIG. 4). The protoplasm of the vesicle was vacuolate and the wall slightly thickened. In the course of the maturation of this structure which may be considered the sporangium, the protoplasm passed through a strongly vacuolate stage, the vacuoles becoming areolate; circlets of droplets then appeared and formed a well defined reticulum. During maturation up to 5 or more prominent papillae were formed on the surface of the wall (FIG. 5). Two to three hours after the emission of the vesicle its contents had become cleaved



FIGS. 1-8. *Myrophagus ucrainicus*.

into many uniform segments—the zoöspores. These subsequently emerged through slightly elevated pores formed upon the deliquescence of the previously mentioned papillae (FIG. 8).

The zoöspores (FIG. 6b), which are more or less irregularly ovoid or ellipsoidal, are often attenuated at the ciliated end and terminate anteriorly in a broad lobobodium. The plasma is finely granular at the extremities and coarsely granular in the midregion. It is not clear from the notes whether or not the granulations mentioned are refractive. From the figures the body of the spore always appears slightly gibbose. One or occasionally two (FIG. 6a)

or three cilia about twice the length of the body project from the rear. The notes indicate, however, that one cilium is considered the typical number. The period of motility in hanging drops varies from 2-3, up to 5 hours, after which the zoöspores become amoeboid and encyst. Upon germination each zoöspore produces a somewhat irregular, unbranched tube from its spherical, uni-guttulate body. No other stages of development are given. One sketch shows two zoöspores fused laterally (FIG. 7) but their further fate is not recorded.

From even the somewhat fragmentary observations of Wize and Thaxter it is evident for several reasons that the fungus cannot be placed in *Olpidiopsis*. In this genus the resting stage arises as the result of a sexual process involving the fusion of the contents of a receptive cell and one or more companion cells. The resting body resulting from this fusion does not ordinarily lie loosely within the receptive cell, but rather the whole structure is transformed into the resting spore. There is therefore, no surrounding wall distinct from that of the resting spore itself. Further, in *O. Schenkiana*, where germination of the resting structure has been observed, the spore itself produces a tube and functions as a sporangium, no external vesicular structure being formed as in the present fungus. Lastly, in *Olpidiopsis* the zoöspores are biciliate and have the cilia laterally, not posteriorly, attached.

In *Woronina glomerata*, Zopf (2), a parasite of uncertain relationships, found in *Vaucheria*, reticulate resting spores similar to those of the present fungus are formed. However, upon their germination, the majority of the zoöspores are produced within the resting cell and are discharged through a tube to the outside of the alga. The present fungus also resembles to some degree a species of *Olpidium*, but wherever germination of the resting spores has been observed in this genus, the zoöspores are formed within the resting body and discharged through a tube. Perhaps the closest resemblance in resting spore germination is to be found in that of the genus *Micromyces* and of those species of *Synchytrium* ordinarily placed in the subgenus *Pycnochytrium*. Here, the resting body acts as a prosporangium, the protoplasm being discharged into an exterior vesicle where a sorus of sporangia is formed. Thaxter's fungus differs from these genera, however, in

that its "vesicle" becomes transformed into a single, multiporous sporangium.

Since the unique characters of Wize and Thaxter's fungus distinguish it not only from *Olpidiopsis* but also from other related forms, it is placed in a new genus, as proposed by Thaxter and given the name suggested by him.

Myrophagus Thaxter, gen. nov.

Vegetative thallus endobiotic, so far as known, an ellipsoidal or spherical walled body which at maturity forms endogenously a single resting spore; resting spore upon germination cracking open and extruding a vesicular structure which becomes a sporangium; zoöspores posteriorly uniciliate, formed within the sporangium, escaping through one or more pores; method of infection and early development unknown.

Visibilis thallus ellipsoidal vel globosus, maturitate perdurantem sporam singulam formans; spora perduranti fractione sporangium vesiculare liberum formante; zoösporis postice uniciliatis endogenis per poros 1-5 liberatis. Infectionis modus et status juvenalis ignoti.²

M. ucrainicus (Wize) Sparrow, comb. nov.

Syn. *Olpidiopsis ucrainica* Wize in, Akademija Umiejętności Krakow (Bull. Intern. Cl. Sci. Math. nat.) 1904: 715. fig. 1, a-g. 1905.

Resting spore spherical, 20-72 μ in diameter, borne singly and loosely in an ellipsoidal (55-71 $\mu \times$ 49-66 μ) or spherical (35 μ in diameter) sac-like structure, the outer wall golden, raised in a series of polygonal reticulations, the inner wall smooth; sporangium formed at germination 50-86 μ in diameter; zoöspores ellipsoidal or ovoid, somewhat gibbose and attenuated posteriorly, contents with numerous granules, cilium 2-3 times length of body, emerging through up to 5 slightly elevated pores.

In larvae of *Cleoni*, *Anisoplia*, The Ukraine (U. S. S. R.), Wize; dipterous pupae, Thaxter, Kittery Pt., Maine, collected Sept. 18, 1902.

Material examined: Thaxter no. 994. Farlow Herbarium.

² In am indebted to Prof. H. H. Bartlett for the Latin diagnosis of *Myrophagus*.

BIBLIOGRAPHY

1. Wize, C. "Choroby Komośnika buraczanego (*Cleonus punctiventris*) powodowane przez grzyby owadobójcze, ze szczególnen uwzględnieniem gatunków nowych." Akademija Umiejetności Krakow (Bull. Intern. Cl. Sci. Math. nat.) 1904: 713-727. figs. 1-11, pl. 15. 1905.
2. Zopf, W. "Ueber einige niedere thierische und pflanzliche Organismen, welche als Krankheitserreger in Algen, Pilzen, niederen Thieren und höheren Pflanzen auftreten." Beiträge Physiol. Morph. niederer Organismen 4: 43-68. pl. 2, 3. 1894.

EXPLANATION OF FIGURES

FIGS. 1-8. *Myrophagus ucrainicus*. FIGS. 1-3, from herbarium material, $\times 450$; FIGS. 4-8, from Thaxter's camera lucida sketches.

FIG. 1, ellipsoidal body within which a resting spore will be formed; 2, surface view of resting spore within its sac; 3, optical section of same; 4, sporangium which has emerged from germinated resting spore; two papillae visible; 5, sporangium free from resting spore, showing 5 visible papillae; 6a, biciliate zoospore; 6b, uniciliate, typical zoospore (these were drawn at the same magnification); 7, two zoöspores apparently conjugating, magnification not given; 8, nearly empty sporangium showing exit pores.

Figures inked in by Richard Higgins.

MYCELIAL HABIT IN SOME SPECIES OF TAPHRINA

A. J. MIX

(WITH 2 FIGURES)

The genus *Taphrina* is in general characterized by intercellular or subcuticular mycelium. Many species, like *Taphrina deformans*, form intercellular vegetative mycelium and a subcuticular ascogenous layer. Other species, as *T. Betulae*, *T. carnea*, *T. caerulescens*, etc., are reported as having mycelium that is subcuticular only, never intercellular. Sadebeck (5) makes this difference in mycelial habit one of the distinguishing characters between his genera *Exoascus* and *Taphrina*.

Two species have been described which depart from both of the above types: *Taphrina laurencia* Giesenhag., and *T. maculans* Butl. The former, which occurs on *Pteris quadriaurita* Retz. is described by Giesenhagen (2) as forming mycelium and ascogenous cells in the outer portion of an epidermal cell of the host, being separated from the host-protoplasm by a thin cellulose wall. It is implied in Giesenhagen's account that the fungus gains entrance to the interior of an epidermal cell and becomes subsequently walled off.

According to Butler (1) the mycelium of *T. maculans* grows at first beneath the cuticle, lying for the most part above the radial walls of the epidermal cells. Flat bands of hyphae pass downward in these radial walls "which are split to give them passage." (Butler loc. cit.) Development of these hyphae may be so great that the lumina of the host-cells become almost occluded by distention of the lateral walls. The fungus also develops in the outer tangential walls of the epidermal cells, and growth of the mycelium may depress the inner layer of the wall almost to the obliteration of the cell cavity beneath.

The writer's interest in this type of mycelial habit among species of *Taphrina* was aroused by a study of *Taphrina californica*

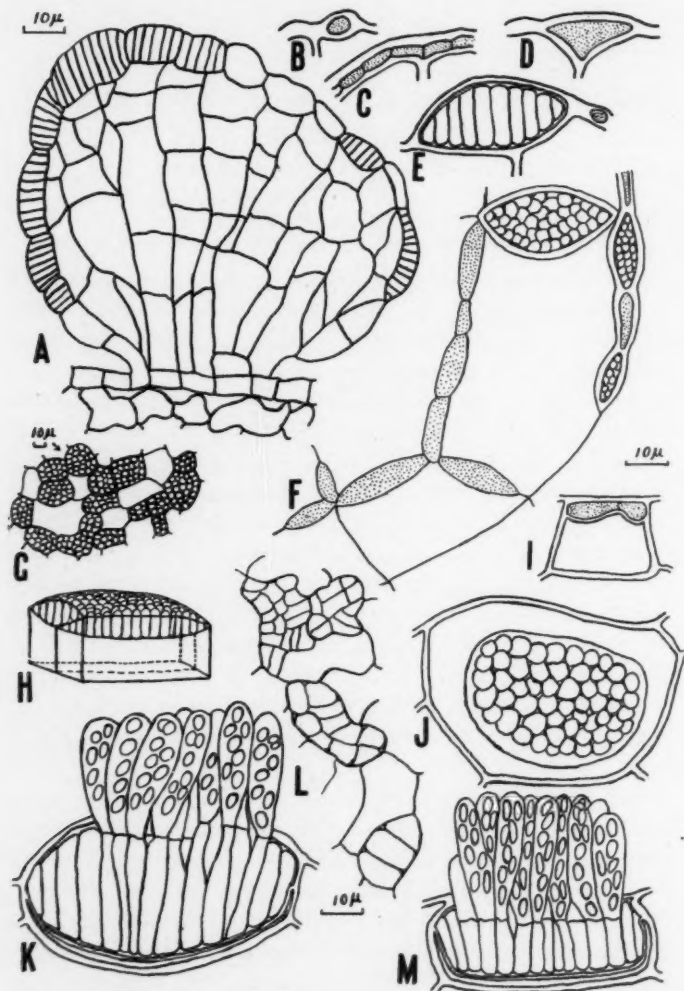


FIG. 1. *A*, young gall caused by *T. californica*, with ascogenous cells of the fungus in the outer cells; *B*, *C*, *D*, mycelium of *T. californica* growing within epidermal walls; *E*, ascogenous cells of the same in a wall-locule; *F*, surface view of a portion of a gall, showing growth of mycelium above radial walls of host cells; *G*, surface appearance (at lower magnification) of gall with ascogenous cells; *H*, diagram to show development of asco-

Mix (4), which causes galls on the leaves of *Dryopteris arguta* (Kaulf.) Wats. This study led to examination of certain other fern-inhabiting species and to re-examination of *T. laurencia* and of *T. maculans*. The results are here presented.

TAPHRINA CALIFORNICA

The fungus was collected at Lake Phoenix, Marin County, California, September 4, 1930, by H. E. Parks and distributed (California Fungi no. 403) under the name *Taphrina filicina* Rostr. This material shows ascogenous cells but no asci. Ascus-bearing galls were found in material especially collected for the writer by Dr. Lee Bonar, November 28, 1937. Early stages of the galls were found in a collection made by Victor Duran, August 21, 1930.

The first stages of gall-development were not found, as the youngest galls examined consisted of several cells. It is clear, however, that the gall is epidermal in origin, arising by repeated tangential divisions of cells of the epidermis (FIG. 1, A). The new cells thus produced become greatly enlarged, especially in a radial direction, have thin walls and are devoid of chlorophyll. Each cell on the surface of the gall was originally the outer portion of an epidermal cell of the leaf. For convenience these may be called epidermal cells of the gall. They are covered by a thin cuticle, approximately as thick as that on the healthy part of the leaf. After a gall has become much enlarged, some hyperplasia may occur in the cells of the mesophyll, but this is a secondary event, and does not alter the fact of the epidermal origin of the gall.

In young galls early stages of mycelial growth may usually be observed at the margin where the gall joins the leaf, even though on other parts of the gall-surface ascogenous cells have already been formed.

genous cells of *T. californica* in a "trough" above the radial wall between two epidermal cells; I, mycelium of *T. laurencia* in the outer wall of an epidermal cell; J, ascogenous cells of *T. laurencia* from above, the host cells being incompletely covered by the fungus; K, asci of *T. amplians* protruding from a wall-locule; L, ascogenous cells of *T. rhomboidalis* from above; M, asci of *T. Tonduziana* protruding from a wall-locule.

No mycelium is ever found in the interior of the gall. It is confined to the surface and invariably begins its development (FIG. 1, B, C) within the outer epidermal wall. Treatment of sections with chloriodide of zinc shows that the mycelium grows between two layers of cellulose, the outer layer being covered by a thin cuticle.

In early stages the mycelium frequently grows above the radial walls of the epidermal cells (FIG. 1, F). As the hyphae broaden and thicken, the separated layers of the wall spread apart and the mycelium lies in a locule formed within the cell wall (FIG. 1, D). The locule is finally filled with close-packed, elongate ascogenous cells (FIG. 1, E). Frequently the locule appears as a trough above the radial wall between two epidermal cells (FIG. 1, H).

These locules, filled with ascogenous cells, together with the host cells unoccupied by the fungus, present a characteristic reticulate pattern (FIG. 1, G) when viewed from above.

When asci form, they burst the outer wall-layer and protrude from the locule as from a perithecium.

TAPHRINA LAURENCIA

This fungus has been studied from herbarium material (Sydow, *Fungi Exotici Exsiccati*, 421. Hakgala, Ceylon 3. 1914. T. Petch) borrowed from the University of Wisconsin Herbarium. It causes remarkable, branched outgrowths on the leaves of its host.

The outgrowths apparently represent modified leaves or leaflets and possess an upper and lower epidermis with a thin cuticle and interior mesophyll containing veins. The fungus is found in both epidermal layers of the outgrowth, the appearance being as described by Giesenhagen (2).

Actually the mycelium begins its development within the wall (FIG. 1, I) as in the preceding case. (In fact, one of Giesenhagen's figures shows this.) Enlargement of the mycelium and formation of ascogenous cells and asci depress the underlying wall-layer until the lumen of the epidermal cell is nearly closed.

This fungus differs from *T. californica* in that the mycelium does not grow above the radial walls of the epidermal cells but spreads over the outer wall of nearly every cell. The character-

istic pattern seen in tangential views of the *Dryopteris*-galls is therefore lacking. Often the mycelium fails to cover a cell completely, resulting in an appearance as shown in figure 1, J.

Dimensions of *T. laurencia* have somewhat wider limits than as given by Giesenhagen: asci $23-33\ \mu \times 6-8\ \mu$; stalk cells $17-30\ \mu \times 4-7\ \mu$; spores $5-7\ \mu \times 2-4\ \mu$.

TAPHRINA RHOMBOIDALIS

Another species, *Taphrina rhomboidalis* Sydow and Butl., occurs on the same host, *Pteris quadriaurita*. Instead of the remarkable outgrowths induced by *T. laurencia* this fungus causes small, unthickened spots. Since these spots are definitely bordered by the veins (although more than one vein-islet may be involved) they are distinctly rhomboidal in outline.

Two peculiarities of *T. rhomboidalis* were overlooked in the original description (7), first, that the ascus possesses a stalk cell, and second, that mycelium and ascogenous cells develop within wall-locules. The habit is quite like that of *T. laurencia*. When seen in surface view, however, the ascogenous cells are not regularly polyhedral in outline, as is the case with other species here discussed. On the contrary they are irregular in shape (FIG. 1, L).

The description of *Taphrina rhomboidalis* should be emended to include the features just mentioned and dimensions should be stated as follows: asci $23-43\ \mu \times 8-10\ \mu$; stalk cells $23-43\ \mu \times 4-5\ \mu$; spores $4-7\ \mu \times 2-3\ \mu$.

These dimensions are close indeed to those given above for *T. laurencia*. In fact there are only slight morphological distinctions between the two fungi. The distinguishing features of *T. rhomboidalis* are a somewhat narrower stalk cell and the irregular pattern of the ascogenous cells when viewed from above. The two species must be separated chiefly by the host-lesions which they induce. These are so strikingly different that it seems unlikely they could be caused by the same fungus. However, the occurrence on the same host of two species so similar as these finds no parallel elsewhere in the genus *Taphrina*.

The foregoing observations on *T. rhomboidalis* were made from material forwarded to the writer by G. Watts Padwick, Imperial Mycologist, New Delhi, India, at the instance of Dr. E. J. Butler.

This was evidently duplicate material of the type, having been collected in the Barma Gori Valley, Kumaon, Himalaya, June 24, 1907, by Inayat Khan.

TAPHRINA TONDUZIANA

A third species, *Taphrina Tonduziana* P. Henn., occurring on *Pteris aculeata* Sav. is also like *T. laurencia* in habit. It has been studied from original herbarium material collected at San Jose, Costa Rica, 1900, by A. Tonduz (Specimen borrowed from the Herbarium of the University of Michigan). This fungus causes small (5 mm. or less in diameter) brown unthickened spots on the leaves. The asci are formed in the central area of each spot on either the upper or under surface or on both. The lesions are like those caused by *Taphrina lutescens* Rostr. on leaves of *Thelypteris thelypteris* (L.) Nieuwl.

As in the species just discussed, two peculiarities of *T. Tonduziana* were overlooked in the original description by Hennings (3): "ascis caespitosis, clavatis, apice rotundatis, vel subapplanatis, 8-sporis, $16-24\ \mu \times 6-8\ \mu$." The asci possess stalk cells (asci $20-30\ \mu \times 7-8\ \mu$; stalk cells $10-17\ \mu \times 5-7\ \mu$; spores $5-7\ \mu \times 2-3\ \mu$), and the fungus displays the "wall-habit" of growth. Mycelium grows within the outer wall of an epidermal cell, ascogenous cells are formed in a wall-locule, and the asci burst out of the locule exactly as in *T. laurencia* (FIG. 1, M).

Taphrina amplians sp. nov.

Mycelio in loculis in muris cellularum epidermidis utraeque paginae folii crescente; ascis ex illis loculis erumpentibus, aureis, clavatis, apice rotundatis vel truncatis, $26-36\ \mu$ longis $\times 8-10\ \mu$ crassis, cellula basilari cylindrata, $23-40\ \mu \times 5-8\ \mu$; ascosporis octonis, hyalinis, $5-6.5\ \mu \times 2-3\ \mu$. Folia aurea colorans et illa longiora latioraque sed non crassiora reddens. In foliis vivis *Pteridis orizabe* Mat. et Gal. Santa Maria de Jesus, Quetzaltenango, Guatemala, December 28, 1936, leg. J. H. Faull.

Mycelium developing in wall-locules of the epidermis of each surface of the leaf, at maturity bursting out of these locules; ascogenous cells and asci colored golden yellow, asci clavate, rounded or truncate at apex, $26-36\ \mu \times 8-10\ \mu$; stalk cells cylindric, $23-40\ \mu \times 5-8\ \mu$; ascospores eight, hyalin, $5-6.5\ \mu \times 2-3\ \mu$. Inducing considerable expansion of leaf blade but no thickening. Affected areas colored golden yellow. Attacking living leaves of *Pteris orizabe* Mat. and Gal.

Type material: Herbarium of J. H. Faull, No. 12939.

For material of this fungus and for permission to describe it, the writer is indebted to Dr. J. H. Faull. Determination of the host-species was kindly made by Mr. C. A. Weatherby of the Gray Herbarium.

Affected leaflets are shown in figure 2, *B*. Development of



FIG. 2. Portions of fronds of *Pteris orizaba* affected by *T. amplians*. Diseased leaflets are laterally enlarged but not thickened.

mycelium, ascogenous cells and asci takes place within the outer epidermal wall. The fungus is like *T. laurencia* in growing above the cell cavities, not above the radial walls between epidermal cells. It is unique among all known species of *Taphrina* on ferns in that its ascogenous cells and young asci contain a golden-yellow, oily substance, thus resembling *Taphrina aurea*, *T. flava*, etc. Mature asci of *T. amplians* are shown in figure 1, *K*.

***Taphrina Thaxteri* sp. nov.**

Mycelio in loculis in muris cellularum epidermidis paginae inferioris folii crescente; ascis hypophyllis, ex loculis erumpentibus, clavatis, apice rotun-

dati vel truncatis, 20–27 μ longis \times 5–7 μ crassis, cellula basilari cylindrata, 7–15 $\mu \times$ 5–7 μ ; ascosporis saepe fusiformis, 3.5–5 $\mu \times$ 2–3 μ . Maculas flavas parvas (usque ad 1 cm. diam.) gignens in foliis *Dryopteridis Poiteanae* (Bory) Urban. Haud deformans. Verdant Vale, Arima, Trinidad. leg. R. Thaxter.

Mycelium growing in locules in walls of lower epidermal cells, asci hypophyllous, emerging from the locules, clavate, rounded or truncate at apex, 20–27 μ long \times 5–7 μ wide; stalks cells 7–15 $\mu \times$ 5–7 μ ; spores often spindle-shaped 3.5–5 $\mu \times$ 2–3 μ . Causing pale-yellow, small (1 cm. or less) unthickened spots on leaves of *Dryopteris Poiteana* (Bory) Urban. Verdant Vale, Arima, Trinidad. R. Thaxter.

Type material in Mycological Herbarium, University of Kansas and in Farlow Herbarium.

This fungus from among the Thaxter collections in the Farlow Herbarium (the packet bears no date) was received from D. H. Linder. The host-species was determined by C. A. Weatherby of the Gray Herbarium.

Taphrina Thaxteri bears close resemblance to *T. Tonduziana* not only in its habit of growth within the wall, but in the size of its asci and stalk cells. It differs in the shape and dimensions of its spores and in possessing a hypophyllous hymenium (amphigenous in *T. Tonduziana*). The host plants are not closely related and unless later collections show similar fungi on a variety of fern-species, it seems unlikely that the two species here distinguished will later prove to be identical.

TAPHRINA MACULANS

Through the kindness of Dr. D. H. Linder, of the Farlow Herbarium, the writer has been privileged to examine material of *Taphrina maculans* Butl. on *Curcuma longa* L. The excellent account of Butler (outlined earlier in this paper) has been confirmed. Butler, however, speaks of the early "subcuticular" growth of the mycelium when he apparently means lateral growth within the wall. The fungus seems to grow within the wall from the first.

TAPHRINA LINEARIS

In the description of *Taphrina linearis* Sydow, occurring on *Globba marantina* L., the authors Sydow and Sydow (6) do not

discuss the growth of this fungus within the host-cell wall. However, the technical description is given in language identical with that employed by Butler (1) in describing *T. maculans*: "hyphis sterilibus inter parietes cellularum epidermidis et hypodermidis crescentibus." It is probable that they were here referring to growth within walls rather than between them.

Material of this fungus (also received from the Farlow Herbarium) shows it to be like *T. maculans* in mycelial habit.

DISCUSSION

The eight species of *Taphrina* discussed above constitute a group, set off from other species by their habit of growth within cell walls, this "wall-habit" reaching its greatest development in *T. maculans* and *T. linearis*. Were there any point in recognizing subgenera, these eight species might be included in the subgenus *Taphrinopsis* of Giesenhagen (2). This subgenus, which till now has included only *Taphrina laurencia*, was proposed for forms developing within epidermal cells. The subgeneric description would, of course, need to be revised.

In the present imperfect state of our knowledge of the genus *Taphrina*, it would be idle to conjecture whether the "wall-type," the subcuticular, or the intercellular type of mycelial habit is the more primitive. Certainly the "wall-type" was reached early in the development of the genus, since six of the eight species exhibiting it occur on ferns. The other two, however, parasitize monocotyledons.

Separation of the wall-layers by these forms does not appear to be by mechanical splitting. Swelling of the walls with sulfuric acid does not show any distinct lamination which would allow for such splitting. It seems more probable that the fungi secrete a cellulose-dissolving enzyme. However, cellulose is apparently not utilized to any extent, since the two layers of the divided wall, taken together, are not measurably thinner than the undivided wall. In the case of *Taphrina californica* the wall separating the fungus from the epidermal cell beneath seems to undergo some additional thickening, presumably due to protective reaction on the part of the host protoplasm. This wall is often noticeably thickened, colors deeper yellow than other walls when treated with sulfuric acid, and is the last wall to dissolve in that reagent.

SUMMARY

Eight species of *Taphrina*: *T. californica*, *T. laurencia*, *T. rhomboidalis*, *T. Tonduziana*, *T. amplians*, *T. Thaxteri*, *T. maculans*, and *T. linearis*, form mycelium within the outer wall of the host-epidermal cell, and produce ascogenous cells and asci in a wall-locule. This fact has been previously reported only for *T. maculans* (a fungus which also develops mycelium within the radial epidermal walls), although *T. laurencia* was described by Giesenhagen as occurring within the outer part of an epidermal cell. Six of these wall-inhabiting species parasitize ferns, the other two are found on monocotyledons.

Two of the above-named species: *Taphrina amplians*, occurring on *Pteris orizabe*, and *T. Thaxteri* on *Dryopteris Poiteana* are new to science. Two others, *Taphrina rhomboidalis* and *T. Tonduziana* were till now inadequately described.

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LITERATURE CITED

1. **Butler, E. J.** The leaf spot of turmeric (*Taphrina maculans* sp. nov.). Ann. Myc. 9: 36-39. 1911.
2. **Giesenhagen, K.** Ueber hexenbesen an Tropischen farnen. Flora 76: 130-156. 1892.
3. **Hennings, P.** Fungi costaricensis. I. Beiblatt zur Hedwigia 41: 101-105. 1902.
4. **Mix, A. J.** Species of *Taphrina* on North American ferns. Mycologia 30: 5: 563-579. 1938.
5. **Sadebeck, R.** Die parasitischen Exoasceen, eine monographie. Jahrb. Hamburg. Wissensch. Anst. 10: 5-110. 1893.
6. **Sydow, H. & P. Sydow.** Diagnosen neuer philippinischer pilze. Ann. Myc. 12: 545-576. 1914.
7. **Sydow, P. & E. J. Butler.** Fungi Indiae Orientalis. Ill. Ann. Myc. 9: 372-421. 1911.

A CANKER DISEASE OF POPLARS CAUSED A NEW SPECIES OF NEOFABRAEA

G. E. THOMPSON¹

(WITH 3 FIGURES)

The disease was first observed at Bear Island, Lake Temagami, Ontario, during the summers of 1930-1931, when it was found on young trees of *Populus grandidentata* Michx., *P. tacamahaca* Mill. and *P. tremuloides* Michx. Later it was found on the same species of poplars in other places in the Temagami Forest Reserve. The affected trees were from three to six years old and usually not over 1.5 inches in diameter.

Cankers were generally located near the base of the tree, although occasionally they were found on the stem a few feet above the ground. In a few cases cankers had caused the death of trees.

SYMPTOMS

Incipient infections appear as small depressed areas in the bark. These are frequently accompanied by a swelling at the margin and a longitudinal splitting of the bark in the central portion of the lesions. Older cankers may be from four to six inches in length, elliptical in outline and girdling the stem for one-half or more of its circumference. The bark in the center of the canker is slightly sunken and split vertically, especially at the margins adjacent to the callus (FIG. 1A). In some cases, cankers completely encircle the stems without any callous formation. They appear as slightly sunken areas surrounding the stem.

In a cross section through the cankered area, the wood is brown-

¹ The investigations reported in this paper were undertaken during the tenure of a scholarship from the National Research Council at the University of Toronto, Toronto, Canada, during 1930-1931. They were continued at Cornell University, Ithaca, N. Y. The author wishes to express his sincere thanks to Professor H. S. Jackson and Dr. J. W. Groves for their assistance in the identification of the fungus. All photographs, with the exception of figure 1B, were made by Mr. W. R. Fisher of the Department of Plant Pathology, Cornell University, Ithaca, N. Y.

ish in color. The discoloration often extends to the pith in a wedge-shaped formation or it follows certain of the annual rings for part of the way around the circumference.

ETIOLOGY

Perfect stage: The perfect stage of the fungus which causes the disease is a small discomycete which possesses certain characters resembling members of the family Dermateaceae. At the suggestion of Dr. J. W. Groves it was compared with material of *Neofabraea malicorticis* (Cordley) Jackson. As a result of the examination, it is concluded that the two fungi are congeneric.

The genus *Neofabraea* was erected by Jackson (2) with the following diagnosis: "Characteristics in general like *Pseudopeziza*. Apothecia developing in and at length breaking forth from a more or less exposed subiculum consisting of the old conidial bearing stroma. Spores at first one-celled at length two-four celled." His species *N. malicorticis*, has for its conidial stage *Gloeosporium malicorticis* Cordley. Jørgensen (3) described a second species in the genus as *N. corticola* (Edgerton) C. A. Jørg. which has for its conidial stage *Myxosporium corticolum* Edgerton.

Nannfeldt (4) after an examination of *Neofabraea corticola* made the genus a synonym of *Pezicula* Tul. and erected the new combinations, *Pezicula malicorticis* and *P. corticola*. He also transferred the conidial stages to the genus *Cryptosporiopsis* Bubak and Kabat (1) which has oblong-ellipsoid conidia. In making the transfer of the genus *Neofabraea* to *Pezicula* Nannfeldt apparently did not see the type of the genus, *N. malicorticis*, but based it on material of *N. corticola* which is a good *Pezicula* and should have been placed in that genus originally. It appears therefore, that the genus *Neofabraea* while probably related to *Pezicula* and other genera of the Dermateaceae through the characters of the apothecia and conidial stages should not be regarded as a synonym of *Pezicula* but as a good genus.

A survey of the literature shows that no species of this genus has been reported as a parasite on poplars. It is therefore described as a new species and the following name is proposed:

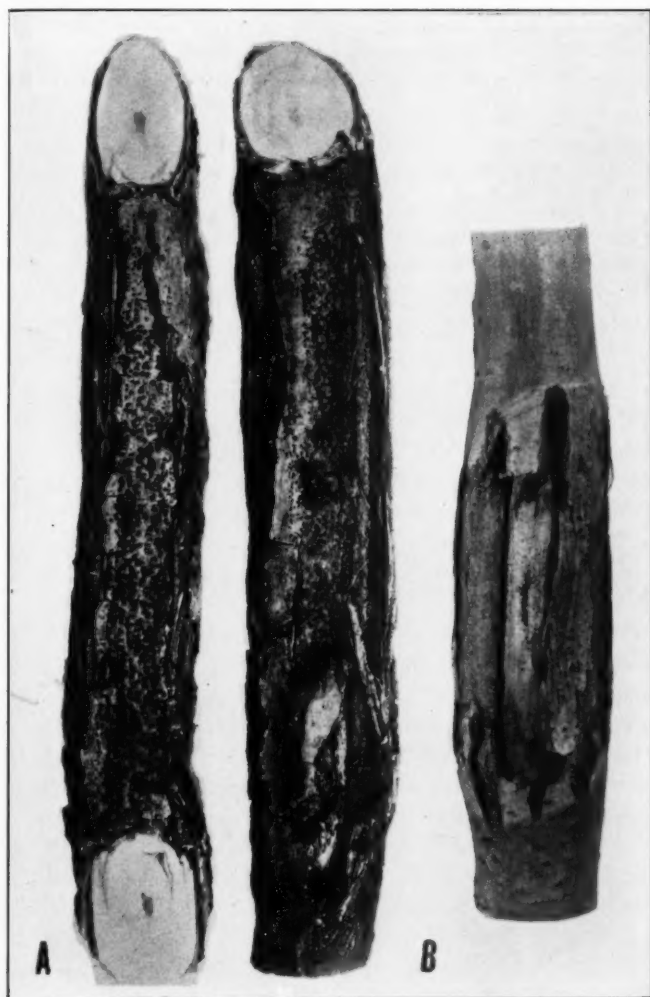


FIG. 1. A, cankers on *Populus tremuloides*, approx. $\times 1$; B, canker on *P. grandidentata* with part of bark sloughed away, approx. $\times 1$.

Neofabraea Populi sp. nov.

Apotheciis leniter erumpentibus, solitariis, dense sparsis, 0.5–1.5 mm. diam., carneis vel brunneolis, carnosus vel ceraciis, umbilicatis, convexis in humido, planis in exsiccatis, stromatis prosenchymaticis, hyalinis; asci cylindrico-clavatis, brevismis stipitatis, $80\text{--}115 \times 9.5\text{--}12.5 \mu$, octosporis; ascosporis, irregulariter distichis, elliptico-oblongis, rectis vel leviter curvatis, hyalinis, continuis vel triseptatis, $16\text{--}22 \times 5\text{--}6.5 \mu$; paraphysibus filiformibus, septatis, simplicibus vel ramosis $2\text{--}3 \mu$ diam. apice incrassato, hyalinis, epithecium formantibus.

Status conidicus; acervulis 0.5–1.5 mm. diam., leniter erumpentibus, sparsis, stromatis, prosenchymaticis, hyalinis; hyphis fertilibus, hyalinis, septatis, simplicibus vel ramosis, $25\text{--}35 \times 4 \mu$; conidiis cylindraceutis vel fusiformibus, rectis vel curvatis, hyalinis, continuis, $25\text{--}45 \times 4.5\text{--}5 \mu$.

TYPE LOCALITY: Bear Island, Lake Temagami, Ontario, Canada.

TYPE SPECIMENS: Author's number 494 on *Populus tremuloides* Michx. Specimens from the same collection have been deposited in the Department of Botany, University of Toronto, Toronto, Canada, as number 2046, and in the Department of Plant Pathology Herbarium Cornell University, Ithaca, N. Y., as number 23994. Specimens have also been placed in the New York Botanical Garden Herbarium.

Mature apothecia were collected during June, July and August. They are scattered thickly over the dead bark. The majority of the apothecia occur singly, a few confluent (FIG. 2A). A few apothecia were found on the exposed wood where the bark had sloughed away from the canker. The apothecia are flesh-colored to light-brown when fresh, becoming darker when dry, fleshy to waxy in consistency, 0.5–1.5 mm. in diameter, convex when moist, flat to slightly concave when dry, circular to irregular in outline, umbilicate, except when produced on the exposed wood, borne on a slight stroma formed between the cork and cortex, finally exposed by rupturing of the outer corky layers; stroma about $100\text{--}150 \mu$ in thickness, composed of loosely arranged, narrow oblong to globose, hyaline hyphae, area immediately beneath the asci composed of narrow compact vertical rows of hyaline hyphae (FIG. 2B and C); excipulum consisting of narrow, brownish obliquely-arranged hyphae; asci cylindric-clavate, short stalked, $80\text{--}112 \times 9.5\text{--}12.5 \mu$, eight spored (FIG. 3A); ascospores irregularly biserial, oblong-ellipsoid, straight to slightly curved, occasionally flattened on one side, contents granular, hyaline, one to four celled, $16\text{--}22$

$\times 5-6.5 \mu$ (FIG. 3C); paraphyses filiform, $2-3 \mu$ wide, hyaline, septate, simple or branched, slightly swollen at the tips (FIG. 3B), forming an epithecium.

Conidial stage: The conidial stage of the fungus is a member of the form genus *Myxosporium*. It frequently was found associated with the apothecia. In several collections, the apothecia occupy the central portion of the diseased area while the conidial stage appears at the margin.

The acervuli $0.5-1.5$ mm. in diameter originate between the cork and cortex of the bark, finally becoming exposed by rupturing of the outer corky layers (FIG. 3D); stroma of the acervulus $35-50 \mu$ in thickness, composed of interwoven, narrow, hyaline hyphae; conidiophores, septate, simple or branched hyaline $25-35 \times 4 \mu$ (FIG. 3F); conidia borne singly at the tips of the conidiophores, cylindric-fusiform, ends slightly pointed, straight or curved, one celled, contents granular, hyaline, $25-45 \times 4.5-5 \mu$ (FIG. 3G) oozing out on the surface of the bark in pinkish masses, whitish when dry.

CULTURES

The fungus was isolated in pure culture from ascospores, conidia and tissue plantings of the diseased bark. The cultures derived from these sources were similar one to another.

Ascospores germinated on potato dextrose agar in three to four hours at laboratory temperatures. A single germ tube developed at the end or side of each spore (FIG. 3D). When ascospores were germinated in sterile distilled water or sterile lake water, narrower germ tubes were formed. Frequently instead of producing germ tubes the ascospores formed numerous oval to elliptical one celled hyaline spores $4.5-8 \times 1.5-2.5 \mu$, resembling microconidia. These were budded off from the sides of the ascospores (FIG. 3E). A similar production of microconidia from ascospores was observed in mounts of crushed apothecia which were kept in moist chambers. No germination of the microconidia was observed.

The conidia germinated on potato dextrose agar in six to seven hours at laboratory temperatures. Germ tubes were produced from the ends or sides of the spores (FIG. 3I).

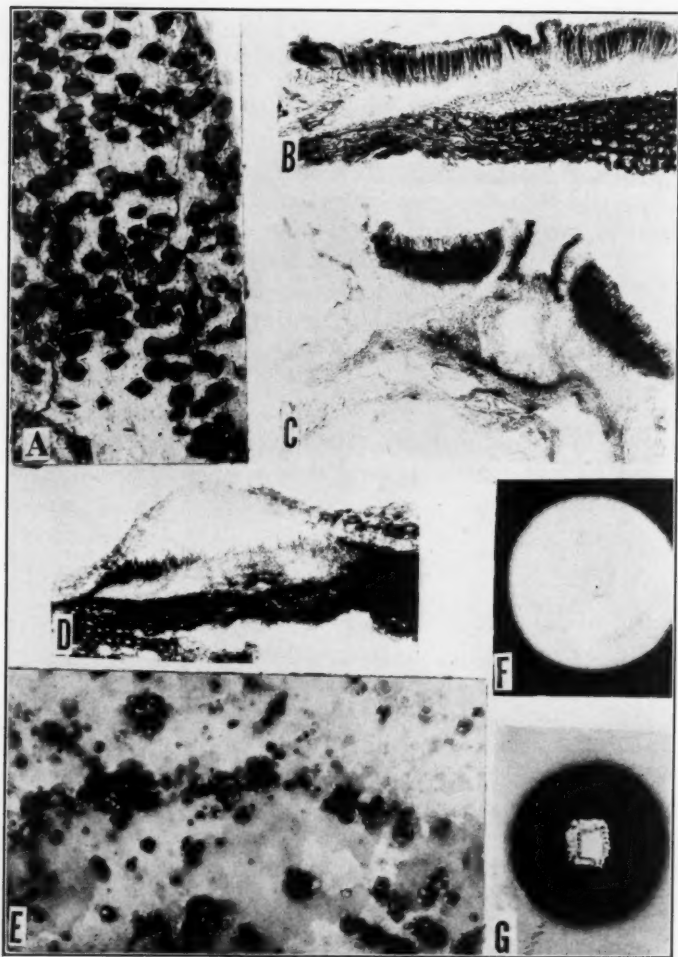


FIG. 2. *A*, mature apothecia on bark of *P. tremuloides*, approx. $\times 3$; *B*, *C*, free hand sections of apothecia stained with cotton blue and mounted in lacto-phenol, approx. $\times 60$; *D*, free hand section of an acervulus stained with cotton blue and mounted in lacto-phenol, showing the stroma with conidiophores and conidia, approx. $\times 60$; *E*, apothecia formed on cornmeal agar, approx. $\times 2$; *F*, mycelial growth of the fungus on potato dextrose agar; approx. $\times 1$; *G*, mycelial growth of the fungus on oatmeal agar, approx. $\times 1$.

The mycelium on potato dextrose agar formed a rather dense cottony aerial growth which later became brownish in patches (FIG. 2F). Conidia were not always formed on this medium.

On oatmeal agar the fungus produced very little aerial mycelium and the medium was stained a dark reddish-brown (FIG. 2G). Conidia were produced quite readily developing within seven to ten days after the cultures were started (FIG. 3H). They appeared as pinkish masses about 0.5–1.5 mm. in diameter exuding from a poorly developed fruiting body resembling an acervulus. The conidia were similar to those found in acervuli in the bark of diseased stems.

On cornmeal agar the fungus appeared as a superficial, loose cottony mycelium, whitish at first, becoming brownish with age. Conidia were produced abundantly within a period of seven days. They developed in fruiting bodies similar to those observed on oatmeal agar.

TEMPERATURE STUDIES

Duplicate sets of petri dishes containing 20 cc. of potato dextrose agar inoculated with pieces of mycelium 5 mm. in diameter were placed in each of the constant temperature chambers. At the end of twenty days the diameters of the colonies were measured and an average obtained for each set of duplicates.

The optimum temperature for growth of the fungus was found to be approximately 18° C. Some growth occurred at 3° and some at 27° C.

Corresponding results were obtained when the fungus was grown at the same temperatures on slants of potato dextrose agar in test tubes. Conidia were present in this series of cultures at temperatures of 3°, 6°, 9°, 12°, 15°, 18°, and a few at 21° C. They were not found in cultures kept at 24° and 27° C. The conidia found in cultures kept at 3° and 6° C. were for the most part atypical. They varied from oval to elliptical, hyaline spores, $6.5-9 \times 3.5 \mu$ to those oblong-ellipsoid to dumb-bell shaped, $13-19 \times 4.5-6.5 \mu$ (FIG. 3J). At temperatures of 9°–18° C. typical conidia were usually produced although at 9° C. both typical and atypical conidia developed.

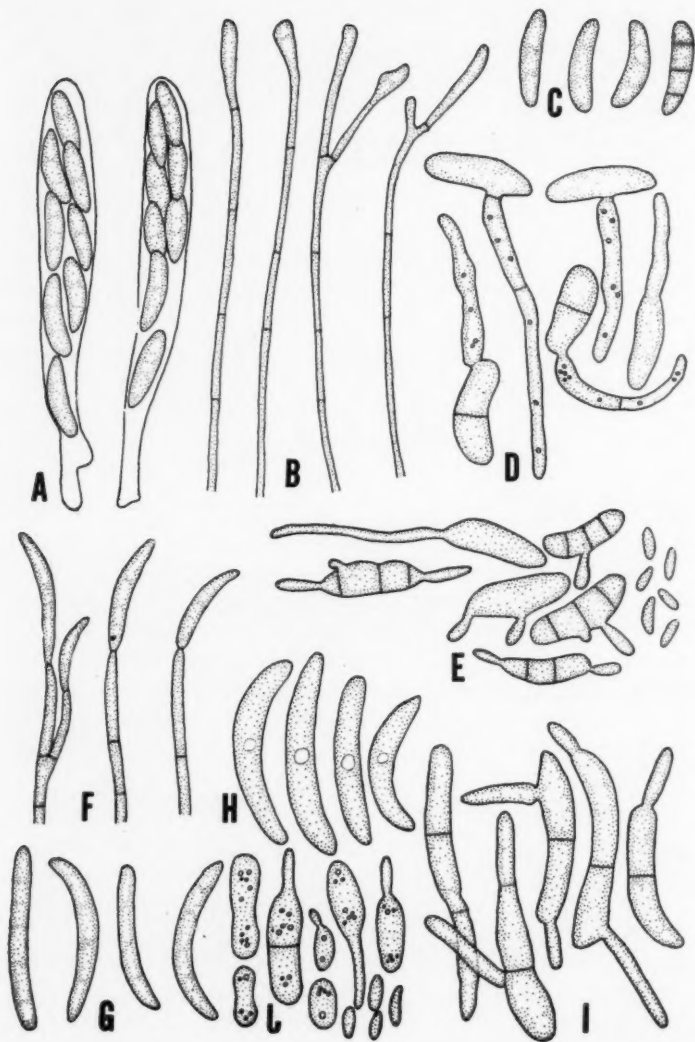


FIG. 3. *A*, asci with ascospores; *B*, paraphyses; *C*, ascospores; *D*, ascospores germinated on potato dextrose agar; *E*, ascospores germinated in sterile distilled water, showing microconidia budding off from the side of the spores; *F*, conidiophores with conidia; *G*, conidia; *H*, conidia produced

PRODUCTION OF APOTHECIA IN CULTURE

On April 6, 1934, transfers from a mass ascospore isolation were made to two petri dishes of cornmeal agar. These petri dishes were placed in the constant temperature chamber at 15° C. On August 7, 1934, the plates were examined and apothecia with mature asci and ascospores were found. Both single ascospores and ascospore masses were isolated and grown on cornmeal agar in petri dishes. The cultures were kept in the constant temperature chamber at 15° C.

During the course of the investigation a total of twenty-three single ascospores were isolated and grown under the above conditions. Five of these produced apothecia with asci and ascospores. The remainder produced sterile apothecia. Seventeen cultures derived from polyascospores were also set up under the same conditions. Twelve of these produced apothecia with asci and ascospores (FIG. 2E), while five yielded sterile apothecia.

The apothecia developed first near the middle of the plate about forty-five days after the cultures were started and later appeared scattered over the surface of the medium. They occurred singly or in groups of two to four, light brown in color, about 1 mm. in diameter, somewhat fleshy to waxy in consistency, convex, paraphyses present. The umbilicate character of the apothecia found in nature was not found in apothecia produced in culture. However the asci and ascospores were similar to those found in the apothecia on the diseased bark.

The sterile apothecia resembled the fertile ones in outward appearance, but the hymenium instead of producing asci was filled with sterile threads resembling paraphyses.

The production of apothecia in culture from single ascospores indicates that the fungus is homothallic. The failure to obtain fertile apothecia in certain cultures may have been due to some unfavorable condition of the environment.

in culture; *I*, conidia germinated on the surface of potato dextrose agar; *J*, atypical conidia found in cultures which were grown at temperatures of 3° and 6° C. *A*, *B*, *C*, *F*, and *G* made from lacto-phenol mounts. Others made from fresh material mounted in water. $\times 835$.

INOCULATIONS

Disease-free trees of *Populus grandidentata* one to four inches in diameter were selected for field inoculations. A "T" shaped slit was made in the bark and an agar block of mycelium from a culture inserted under one edge of the incision. This portion of the stem was enclosed in a celluloid cylinder and the ends plugged with moist sphagnum. The chamber thus formed was left attached to the tree for a period of five days. During that interval the sphagnum was kept moistened.

On July 10 and 28, 1930, seven inoculations were made on the lower part of the stems just above the ground. A different tree was used for each inoculation.

On June 25, 1931, the trees were examined. Six of the seven inoculations were successful. Cankers were developing and acervuli with typical conidia were present around the margins of the affected parts. Isolations of the fungus were made from the conidia and diseased bark. The cultures were similar to those made from ascospores and conidia from naturally infected trees.

SUMMARY

1. A canker disease affecting trees of *Populus grandidentata*, *P. tacamahaca*, and *P. tremuloides* was found in the Temagami Forest Reserve, Ontario, Canada.

2. The fungus causing the disease is described as *Neofabraea Populi*. Its conidial stage is a member of the form genus *Myxosporium*.

3. The fungus was isolated from ascospores, conidia and tissue plantings from the diseased bark and grown on various media. The cultures derived from these sources were similar to one another.

4. The optimum temperature for growth of the fungus was found to be approximately 18° C. Some growth occurred at 3° and at 27° C.

5. Apothecia were developed in pure cultures on cornmeal agar. Both single and polyascosporic isolations produced apothecia in about forty-five days when grown at a temperature of 15° C.

6. The pathogenicity of the fungus was demonstrated by artificial inoculations made to small trees of *Populus grandidentata*. The fungus was re-isolated in pure culture.

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LITERATURE CITED

1. Bubak, F. & Kabat, J. E. Mykologische Beitrage. Hedwigia 52: 340-363. 1912.
2. Jackson, H. S. Apple tree anthracnose. A preliminary report. Oregon Exp. Sta. Crop Pest and Hort. Report. 1911-1912: 178-197. 1913.
3. Jørgensen, C. A. Mykologiski Notitiser 3-10. Bot. Tidsskr. 41: 227-239. 1930.
4. Nannfeldt, J. A. Studien über die Morphologie und Systematik der nicht-lichenisierten inoperculaten Discomyceten. Nova Acta Soc. Sci. Upsal. IV. 8: 1-368. 1932.

NORTH AMERICAN POLYPORES—II. POLYPORUS BIENNIS AND ITS VARIETIES

PAUL W. GRAFF

Polyporus biennis and its varietal segregates possess quite variable characteristics. They have masqueraded among the poroid Boleti and Polypori, the labyrinthine Daedaleae and the echinoid Sistotremae, not to mention that group of contortionists, the genus *Abortiporus*, created by Murrill for the reception of a member of this group. They have finally come to rest, as appears most appropriate, in the genus *Polyporus*.

Of the five fungi considered here *Polyporus biennis*, apparently, has not been collected in North America, but is typically European. The remaining four are varieties of this species. Though the first of these has been reported from the United States this was without justification. Our present knowledge indicates the last three to be wholly American in their distribution.

Bulliard (1789) first described and figured *Polyporus biennis*, and placed it in the genus *Boletus*. A few years later Persoon (1797) conceived a need for the genus *Sistotrema*, and subsequently (1801) included Bulliard's species within this group. As first instituted *Sistotrema* is located between the genera *Boletus* and *Poria*, and contained but two species, *S. confluens*, based upon *Hydnum sublamellosum* Bull., and *S. cinereum*, based upon *Boletus unicolor* Bull. With his customary naivete Persoon changes these specific names without offering excuse or reason.

In his "Synopsis" Persoon extends *Sistotrema* to include twelve species. These are about evenly divided between forms gleaned from the genus *Hydnum*, and near relatives, and from *Boletus* as interpreted by Bulliard. In an appended foot-note Persoon says briefly, "Intermedium genus est inter Boletum et Hydnum." Persoon considered *Sistotrema* as a repository for certain species which he believed transitional in nature and properly located between the Polyporaceae and Hydnnaceae.

Whatever may be the final appearance among old specimens of these fungi they are primarily polyporoid in nature. As they develop, inhibitions may appear in the growth of portions of the tubes or, through the laceration of their dissepiments, a camouflaged state may be produced. Whether this echinoid tendency is of much phylogenetic importance may be considered questionable. While it is admissible that these fungi may show transitional tendencies, they are not sufficiently well marked to exclude them from the Polyporaceae. If *Polyporus biennis* belongs to a group closely related to the Hydnceae what of its labyrinthine pores and their significance?

In his original description Bulliard (1789) describes the pores of *Polyporus biennis* as irregular in form and exceedingly variable. In his plate 449 they are shown as distinctly sinuous and daedaloid. In recognition of this Fries (1821) placed the species in the genus *Daedalea*. Later (1838), however, he concluded that the fungus was primarily polyporoid, and removed it to *Polyporus*.

The basis upon which members of the genus *Polyporus*, having sinuous or labyrinthine pores, are distinguishable from true members of the genus *Daedalea* is frequently overlooked. While necessarily of a more or less relative nature, if taken into account, the species may be readily separated. If applied in the present instance there should be no hesitancy in placing any of the several forms we are to consider in their proper generic position. The presence of labyrinthine pores is not in itself a sufficient diagnostic character, but the nature of these pores, and their dissepiments, may be of considerable importance. Though briefly stated, the following should be sufficient aid in separating members of the genus *Polyporus* with daedaloid pores from true members of the genus *Daedalea*.

DAEDALOID POLYPORE: Tube layer distinct but not separable from the context; tubes of equal length, forming a homogeneous layer; pileus fleshy, leathery to woody, stipitate or sessile, rarely resupinate; context often soft at first, fibrous, spongy, fleshy or firm, rarely suberose or woody; pores slender, narrow, having thin dissepiments whose edges frequently become irregular or lacerate.

DAEDALEA: Tube layer not distinct or separable from the context; tubes immersed in the flesh of the pileus to varying depths;

pileus suberose, sessile or resupinate; context firm, suberose, rarely woody; pores usually broader and more contorted, having corky and relatively thick dissepiments whose edges are more often smooth, when lacerate or toothed such condition does not extend to the marginal pores.

On the basis of the above Bulliard's *Boletus biennis*, and its several varieties as interpreted in this paper, belong in the genus *Polyporus*.

1. *POLYPORUS BIENNIS* (Bull.) Fries, Epicr. Syst. Myc. 433. 1838.

Boletus biennis Bull. Herb. Fr. pl. 449. 1789.

Sistotrema biennis (Bull.) Pers. Syn. Fung. 550. 1801.

Daedalea biennis (Bull.) Fries, Syst. Myc. 1: 332. 1821.

Daedalea albida Purt. Brit. Pl. 3: 253, pl. 38. 1821.

Sistotrema rufescens Pers., var. *bienne* (Bull.) Pers. Myc. Eu. 2: 207. 1825.

Polyporus heteroporus Fries; Quél. Champ. Jura, Vosges 257. 1872. Not Mont.

Daedalea pampeana Speg. Anal. Mus. Nac. Buenos Aires II. 6: 175. 1899.

Daedalea bonariensis Speg. Anal. Mus. Nac. Buenos Aires III. 1: 52. 1902.

Basidiocarp solitary and simple or imbricated from a short, simple stipe, or sessile; pileus convex at first, then plane to depressed, occasionally dimidiate, 3-12 cm. broad when solitary, when imbricated somewhat broader, 0.5-1.5 cm. thick; surface scurfy-tomentose to strigose, becoming more or less subglabrous in age, flesh-colored or light reddish-brown, rarely yellowish, in the center, with a, usually wide, white margin, azonate; margin variable, thin and acute to thick and obtuse, usually fertile below, reflex to repand; context white when fresh, becoming light tan when dry, duplex, with the upper layer soft and spongy and the lower firm and coriaceous, 0.3-1 cm. thick, hyphae rarely branching, with walls of variable thickness, 3-7.5 μ in diameter; tubes white, then flesh-colored to ashen when dry, labyrinthiform or sinuate, very unequal, approximately 48 per sq. cm., somewhat decurrent, dissepiments thin, entire at first, more or less lacerate-dentate in age, frequently pruinose; stipe short, thick, subcentral to lateral, sometimes wanting, 1.5-2 cm. long, 1-5 cm. thick, concolorous with the center of the pilear surface, woody, subtomentose to

lanate; basidia elongate-clavate, $20-30 \times 5-7 \mu$; spores ellipsoid to broadly ovoid, $5-7 \times 3.5-5 (6 \times 4) \mu$, hyaline, smooth, apiculate, with a large central guttation.

TYPE LOCALITY: France.

HABITAT: Decaying wood, tree stumps, roots, and sometimes appearing on soil but then from buried wood.

DISTRIBUTION: Europe; South America; Queensland, Australia (Cooke). Late Autumn.

ILLUSTRATIONS: Bulliard, Herb. Fr. pl. 449. 1789; Nees, Syst. Pilze Schw. pl. 30, fig. 228. 1817; Purton, Brit. Pl. 3: pl. 38. 1821, as *Daedalea albida*; Gillet, Champ. Fr. 5: pl. 161. 1897.

At present any statement regarding the distribution of *Polyporus biennis* must be discounted to a certain extent. This is because of the confusion in identity which has existed between this species and the fungus generally known as *P. rufescens*. For example, we find that Winter (1884) recognizes *P. biennis* and *P. rufescens* as distinct species. He includes *Daedalea rufescens* (Pers.) Fries, in his synonymy of *P. biennis*, and *Sistotrema rufescens* Pers., in that of *P. rufescens*. As *S. rufescens* is the Persoonian fungus which Fries removed to the genus *Daedalea* it is obvious that Winter has not aided in the clarification of the situation. Rea (1922) considers *P. biennis* and *P. rufescens* to be synonymous, and apparently reached this conclusion by accepting Sowerby's interpretation of Bulliard's species without reference to Bulliard's original description and most excellent plate. More definite knowledge respecting the geographic distribution and host range of these two fungi is highly desirable, but the validity of this data depends upon a clearer understanding of their characteristics and distinctions.

In connection with variability of the pores in *Polyporus biennis*, it seems that where these are less daedaloid and more rounded than usual the dissepiments are thicker. Such variation in the Polyporaceae is usually associated with a rapid development and early maturing in the presence of greater humidity and higher temperature than normal. The pores in such cases are frequently more shallow than in the typical state.

It should be noted also that it is only among older and larger forms that the considerably lacerated dissepiments of the pores

give any chance resemblance to members of the Hydnaceae. With regard to the white margin on the upper surface of the pileus there is much variability. In young, rapidly growing specimens this is frequently as wide as a quarter or even half the radius of the cap. In the case of slower growing plants, or older specimens where the growth activities are slowing down, the width of this white margin often becomes much diminished in proportion to the colored center.

In his earlier publication, as I have already pointed out, Fries (1821) transferred *Boletus biennis* Bull., to the genus *Daedalea*, but later (1838) removed the species to the genus *Polyporus*. Subsequently Fries communicated the description of a fungus, under the name of *P. heteroporus*, to Quélet, who published it (1872) in his "Champignons du Jura," where he gives Fries due recognition as the author. Later we find that Quélet (1886), who maintained *P. biennis* as a *Daedalea*, recognized the fact that *P. heteroporus* and *D. biennis* are undoubtedly identical and reduced the former to synonymy.

Another early description of *Polyporus biennis* was published by the English botanist Thomas Purton (1821), who described it as a "Fawn-colored *Daedalea*" under the scientific name of *Daedalea albidula*. His description is accompanied with an excellent colored plate that leaves no doubt as to the fungus with which he was dealing. In connection with his description he says that he adopted Withering's specific name on the same principal that gentleman adopted it from Schaeffer. "The term *albidus*," he says, "by no means applies to the plant in the state I have found it." His plate clearly shows a fungus with the flesh-colored center and white margin, as well as the pore characters, of *P. biennis*. While Purton gives three synonyms, "*Daedalea alba* Batt.," "*Boletus albidus* Schaeff.," and "*Boletus rugosus* Sowerby," he questions all as to identity with his species, and is quite justified in doing so.

It would seem that Purton did not have the excuse Withering (1796) had in appropriating the name *albidula*. The fungus Withering described was, in all probability, the same as that described and illustrated by Schaeffer (1763, pl. 124) as he claimed, and seems to be, without question, *Polyporus albidus* (Schaeff.) Secr., otherwise known as *P. caesius* Fries. "*Daedalea alba*

Batt.," is in the peculiar position of never having existed. We have a strange condition here for the fungus to which Purton refers is designated by Battarra as *Agaricus daedalaeis sinibus excavatus* Tou. Battarra used no such binomial as "*Daedalea alba*" in either this or any other connection. Battarra's (1775, pl. 38, fig. A) plant, to which reference is made, may be the same species as described by Schaeffer, but both description and plate are too inadequate for any satisfactory interpretation. However, one can positively say that this is not the species with which Purton was dealing. In the case of "*Boletus rugosus* Sowerby" (Sowerby 1815, pl. 422), there can be no doubt but that this is *B. rugosus* Pers., a fungus now usually recognized as *Polyporus alligatus* Fries.

While Purton's description is not as complete as one might desire, his plate 38 is an excellent representation of the larger imbricated form of *Polyporus biennis*. It conforms well with the original description offered by Bulliard, and supplements his plate in which the simple type of basidiocarp is shown.

Persoon (1825) recognized the close relationship of *Polyporus biennis* to his *Sistotrema rufescens*, and proposed to make the former a variety of the latter. Apparently Persoon believed his *S. rufescens* to be more general in its distribution than *P. biennis*, and consequently better in the position of species than as a variety. As it happens, however, Fries (1821) had already proposed considering the rufescent variety of this fungus as a variety of *P. biennis* when he recognized Sowerby's (1799, pl. 191) English fungus as differing from that described by Bulliard, and published it as var. *Sowerbei*. By some strange oversight this action of Fries seems to have been entirely overlooked.

Spazzini (1899) described, as *Daedalea pampeana*, a fungus purporting to be a new species from the "Parque de la Plata," and later (1902) another, as *D. bonariensis*, from the vicinity of Buenos Aires. Bresadola (1916) came to the conclusion that these two fungi are identical and placed both as synonyms of *Polyporus biennis*. Saccardo (1925) upholds him in this assumption, and is undoubtedly correct in doing so. Some slight chance of confusion arises, however, when we find that later Bresadola (1931) transferred these synonyms to a position beneath the

rufescent variety. One naturally wonders why this change was made for no reason is given. These both belong, as Bresadola first placed them, among the synonymy of *P. biennis*.

Rea (1922) maintains Fries' early attitude, and considers *Polyporus biennis* a true *Daedalea*. However, we find that he designates it as "*Daedalea biennis* (Bull.) Quél." Fries first described this fungus as a *Daedalea* and later published it as a *Polyporus*. Quélet reversed the action of Fries, and first (1872) concluded the species to be a *Polyporus*. Later (1886) he supported its position as *Daedalea biennis*, and in doing so failed to give Fries due credit. Rea, apparently because of this, was led to believe that Quélet made the original proposal for the use of this name.

There are but two synonyms given by Rea in connection with this species. As these are *Polyporus rufescens* (Pers.) Fries, and *Boletus biennis* Bull., as figured by Sowerby, we must conclude that in his opinion the rufescent form cannot be distinguished from that originally described by Bulliard.

Bresadola (1931) has described and illustrated a fungus purporting to be *Polyporus biennis*. The color of the pileus and stipe is represented as a dirty gray throughout. The pores are shown as large, oval and elongated in the direction of the radius of the cap. They have thick dissepiments. His description is inadequate, and does not apply to either his own colored plate or to the plant as described by Bulliard.

The generally peculiar situation warrants one in assuming that *Polyporus biennis* is not well known in Europe, though supposedly a common fungus. That being the case, it is not surprising that its varieties should also be in a confused state, and even less understood.

2. *Polyporus biennis* (Bull.) Fries, var. *Sowerbei* (Fries) comb. nov.

Sistotrema rufescens Pers. Syn. Fung. 550. 1801. In part.
Daedalea biennis (Bull.) Fries, var. *Sowerbei* Fries, Syst. Myc.
1: 332. 1821.

Polyporus rufescens (Pers.) Fries, Syst. Myc. 1: 351. 1821.
Daedalea rufescens (Pers.) Secr. Mycogr. Suisse 2: 483.
1833.

Polyporus biennis (Bull.) Fries, var. *rufescens* (Pers.), Bres.
Ic. Myc. 20: pl. 958. 1931.

Basidiocarp solitary and simple, rarely imbricated, usually stipitate, but occasionally sessile; pileus convex at first, then plane to depressed and infundibuliform, frequently dimidiate, 5–12 cm. broad, 0.5–1.5 cm. thick; surface strigose or tomentose to hispid, rarely subglabrous in age, ferrugineous to rufescent-brown throughout, azonate; margin variable, thin and acute to thick and obtuse, fertile below, reflexed to repand; context white, changing to isabelline or fawn on drying, duplex, with a soft and spongy upper layer, the lower firm and coriaceous, hardening on drying to woody, 0.3–1 cm. thick; tubes of the same color as the upper surface, sometimes slightly lighter, large, sinuate, rarely extremely daedaloid, sometimes quite angular approaching alveolar, very unequal, averaging 21 per sq. cm., decurrent, dissepiments thin, entire, becoming more or less lacerate-dentate in age; stipe lateral to subcentral, occasionally central, rarely wanting, 3.5–4.5 cm. long, 1–1.5 cm. thick, irregular in shape, rugose, subtomentose, concolorous with the surface of the pileus, interior white; basidia elongate-clavate, $20\text{--}30 \times 5\text{--}7 \mu$; spores ellipsoid to broadly ovoid, $5\text{--}7 \times 3.5\text{--}5$ (6×4) μ , hyaline, smooth, apiculate.

TYPE LOCALITY: England.

HABITAT: Fallen and felled timber and tree stumps, rarely on soil from buried wood.

DISTRIBUTION: Europe; Victoria, Queensland and West Australia (Cooke).

ILLUSTRATIONS: Sowerby, Engl. Fungi, pl. 191. 1799; Bresadola, Ic. Myc. 20: pl. 959. 1931. As *Polyporus perennis*.

As already noted there has been much confusion between *Polyporus biennis* and this rufescent variety. Reference to the works of Sowerby, Fries and Persoon would have prevented the present confusion due, apparently, to a sequence of misinterpretations. Sowerby's plant, upon which this variety is based, is very characteristic and readily distinguishable from the species.

The entire surface, in the case of var., *Sowerbei*, is of the same deep reddish-brown color, though in its younger state the pore surface may be of a slightly lighter shade than upper surface or stipe. It should also be noted that, while in *Polyporus biennis* the pores, midway stipe and margin, average 48 to the sq. cm., in number, in var. *Sowerbei* the average is but 21 to the sq. cm. These larger

pores attain this size by being broader in proportion to their length than in the species. They are consequently more or less sinuous, or irregular, and with less of the close labyrinthiform appearance found in the more compact pore surface of *P. biennis*.

Hard (1908) has reported *Polyporus rufescens* as rather common in the vicinity of Chillicothe. While Hard's description is very brief, it seems probable that he had the form which we will consider next and not var. *Sowerbei*. Thus far I have been unable to locate any authentic reports of this variety from North America. References made by Berkeley, Curetis and Lloyd to *P. rufescens* in the United States will also be considered in connection with the next variety.

When Sowerby (1799) issued his plate 191, with a brief note regarding the collection of this fungus in England, he did not consider the plant a new species but distinctly designated it as *Boletus biennis* Bull. Later Fries (1821) transferred Bulliard's *B. biennis* to the genus *Daedalea* and at the same time recognized the form with which Sowerby was dealing as having certain well marked differences. He published a brief description of it under the name *Daedalea biennis* var. *Sowerbei*. Though this will be readily found in Vol. 1, page 332, of the "Systema," I have not seen a single reference to this act anywhere in the mycological literature.

In the meantime Persoon (1801) had published his *Sistotrema rufescens*. At first Fries considered this to be a distinct species and included it, as *Polyporus rufescens*, in the same volume (p. 351) in which he described his var. *Sowerbei*. Sometime later Fries (1874) expressed the opinion that Persoon's *S. rufescens* did not represent one species but several and that it was, in part, his var. *Sowerbei*. Persoon's (1803) plate 6, labeled *S. rufescens*, is definitely referred by Fries to *P. acanthoides*.

Even Fries, however, is not devoid of fault for we find in his "Hymenomycetes Europaei," as a synonym under *Polyporus biennis*, reference to "*Daedalea rufescens* Pers., Myc. Eu. 2: 206." There is no such citation in this publication by Persoon. Reference to Persoon's publication leaves no doubt but that Fries intended to cite the combination *Sistotrema rufescens* Pers. var. *biennis* (Bull.) Pers. Nor is Persoon, at any time, accountable for the combination *D. rufescens*, but rather Secretan.

The description given by Secretan (1833) would seem to indicate, though he refers to plate 6 of Persoon's "Icones pictae," that he was dealing with the form interpreted by Fries as this rufescent variety of *Polyporus biennis*. It seems that Secretan's *Daedalea rufescens* should be considered here and not among the synonymy with *P. acanthoides*.

Bresadola (1931, pl. 958) illustrates a fungus under the name *Polyporus biennis* (Bull.) Fries, var. *rufescens* (Pers.) Bres. Here again we find a fungus with characteristics little suited to the plant intended. What Bresadola had in this case is difficult to say. If, on the other hand, we refer to his plate 959 we find our var. *Sowerbei* well depicted in the lower figure. The central figure appears abnormal as it shows a tendency toward zonation. The upper figure represents our fungus with the central portion of its upper surface abnormal through what is apparently a secondary growth of the hirsute layer. These appear under the name *P. perennis*, which they most decidedly do not represent.

How Bresadola came to misinterpret so common a fungus as *Polyporus perennis* is difficult to understand. He includes *Xanthochrous perennis* (L.) Pat., among his brief synonymy, and this offers a suggestion. It is possible that he was influenced by Patouillard (1898) who divides his new genus *Xanthochrous* into several sections and refers the first of these to "Perennes Fr., Nov. Symb. p. 71." This citation is incorrect and one does not know whether Patouillard intended, when citing Fries (1851), to refer to "Stirps Perennes" of page 55 or the members of "Stirps Coriacea" of page 71. If the latter were his object why does he include *P. perennis* Fries, as an example, and if the former were his idea why do we find the characteristics of the species Fries describes in his "Stirps Coriacea" used in the genus description? The species included on page 71 of Fries' work are of the anoderm type with "contextu tenacei floccoso" and sinuate, daedaloid pores, quite different in character from the well known *P. perennis*.

The first species recognized by Patouillard in his genus *Xanthochrous* is *Trametes Pini* (Thore) Fries, and this, according to our rules, must be considered the type of that genus. His succeeding comments, however, are such as to make it possible to interpret *Polyporus tomentosus* Fries, as the type, as has been done on

occasion. It is obvious that *P. perennis*, has been misinterpreted by Patouillard and Bresadola. The fungus illustrated by Bresadola in his "Iconographia" under that name represents *P. biennis* var. *Sowerbei*.

3. **Polyporus biennis** (Bull.) Fries, var. **distortus** (Schw.) comb. nov.

Boletus distortus Schw., Schr. Nat. Ges. Leipzig 1: 97. 1822.

Polyporus distortus (Schw.) Fries, Elench. Fung. 1: 79. 1828.

Polyporus abortivus Peck, Bot. Gaz. 6: 274. 1881.

Daedalea abortiva (Peck) Pat., Essai Tax. Hymén. 96. 1900.

Daedalea distorta (Schw.) Pat., Essai Tax. Hymén. 96. 1900.

Abortiporus distortus (Schw.) Murr., Bull. Torrey Club 31: 422. 1904.

Polyporus rufescens (Pers.) Fries, var. *hexagonoides* Lloyd, Letter 40: 2. 1912.

Basidiocarp variable in form and size, frequently solitary, sometimes subcaespitose through the branching of the stipe near the base, occasionally entirely resupinate; pileus fleshy-tough when fresh, thin, plane or depressed, circular, infundibuliform, or irregular in outline, rarely imbricated, often distorted, 3–13 cm. in diameter, 0.3–1.5 cm. thick; surface white to alutaceous, drying light tan or gray, compactly villose-tomentose, rarely approaching glabrous, azonate; margin variable, frequently thin and acute but sometimes thick and obtuse, sterile or fertile below, undulate or lobed; context white, isabelline to light tan on drying, duplex, soft and fibrillose-spongy above, firm and corky below, 0.2–1 cm. thick, hyphae rarely branched, 4–8 μ in diam.; tubes decurrent, white, becoming isabelline on drying, rufescent when bruised, 1–6 mm. long, averaging 1–3 per sq. mm., but exceedingly variable, angular to contorted, or irregular, dissepiments thin, entire to dentate; stipe central to excentric or lateral, sometimes wanting, surface white to tan or gray, tomentose, soft on the outside, firm within, up to 6 cm. long, sometimes rudimentary or tuberculate; basidia 4–5 μ in diameter; cystidia cylindrical, inconspicuous, 5–10 μ in diameter; spores hyaline, smooth, 5–7.5 \times 3–5 (6 \times 4) μ , ellipsoid to broadly ovoid, apiculate.

TYPE LOCALITY: North Carolina.

HABITAT: About stumps, roots, or in humus containing dead and decaying wood of deciduous trees.

DISTRIBUTION: Eastern Canada and United States, south to Louisiana, west to Wisconsin, Missouri and Texas. Also collected in Puerto Rico.

ILLUSTRATIONS: Lloyd, Syn. Stip. Polyp. fig. 456, as *Polyporus rufescens*, and fig. 458. 1912; Myc. Notes 40: fig. 753. 1916; Myc. Notes 69: pl. 236, fig. 2395. 1924, as *P. rufescens*. Overholts, Wash. Univ. Stud. 3: pl. 1, fig. 3, a-b. 1915.

This variety is distinguishable from the preceding by its entirely white or slightly alutaceous pileus and the size of its pores. The pores are usually from 1-3 per sq. mm., and very rarely fewer than 100 per sq. cm., midway stipe and margin. Chlamydospores, 5-8 μ in diameter, have been reported, and Overholts (1914) says that conidia, 5.2-7.8 \times 3.3-4.2 μ , ovoid to elliptical, white and smooth, are sometimes present.

In many cases the distorted, teratological form of this variety will be found, and from this condition the name of the fungus has arisen. The normal plant is not uncommon, however, and should be recognized. The percentage of teratological plants is proportionately high, and most descriptions give great weight to these irregularities of the fungus. The plants assume, however, such a variety of form that it is neither necessary nor of value to consider them in detail.

In the matter of color change it seems that rufescent discolorations are largely due to mechanical injury that has affected the surface. This, also, may be the case with plants approaching a somewhat glabrous state. It will be found that when such color changes appear there has developed a definite change in the texture of the tissues involved. Naturally such changes are of ecological rather than phylogenetic significance.

This variety has also had a devious history. Schweinitz (1822) first described his No. 903, collected in North Carolina, as *Boletus distortus*. He accompanied his description with the suggestion of a possible relationship to *Sistotrema biennis*. Later (1832) he reported his No. 476, from North Carolina and Pennsylvania, under the name *Daedalea biennis*, and included his *Boletus distortus* as a synonym. In doing this he refers definitely to his No. 903 of the previous publication so that there can be no doubt he considered both collections as specifically identical, that his

B. distortus was not a good species and merely the American representative of the European fungus.

Berkeley and Curtis (1856), with, as they say, "a view to place the Mycology of the United States on a firm and stable foundation," published comments upon a number of Schweinitz's species. Here we find No. 476 designated as *Daedalea biennis*, and it is remarked that this is equivalent to *Polyporus rufescens*. It thus becomes evident that Berkeley and Curtis considered *D. biennis*, *P. rufescens* and *Boletus distortus* as botanically identical.

Berkeley (1872) again discusses several American collections deposited in the British Museum. These include four from North Carolina, collected by Curtis, and one from Pennsylvania, collected by Michener. These are designated as *Polyporus rufescens*. From the field notes of M. A. Curtis accompanying these specimens, a bound, typewritten copy of which is in the library of the New York Botanical Garden, it seems that Curtis also considered these as *P. rufescens*. Two of the numbers, according to these notes, are decidedly of the *distortus* form.

Patouillard (1900) also creates an interesting situation with regard to this variety. In the first place he recognizes both *P. abortivus* Peck, and *P. distortus* (Schw.) Fries, as distinct species, and removes them to a genus which he designates as "*Daedalea* Pers., Synops. p. 449." "Le type de ce petit groupe," he says, "est le *Daedalea biennis* Pers." Persoon (1801) discusses the genus *Omphalia* on page 449 of his "Synopsis." The genus *Daedalea* is described on page 499 with *D. quercina* as the type. There is no such fungus as *D. biennis* Pers., and neither is *D. biennis* (Bull.) Fries, nor any of the species Patouillard places in the genus "*Daedalea* Pers.," at this time, included under that generic name by Persoon. It should also be noted that none of the species included in *Daedalea* by Persoon are mentioned as belonging there by Patouillard.

Murrill (1904) established the new genus *Abortiporus* for the reception of *Boletus distortus*. The need for this genus has been seriously doubted, and it has remained with but two possible species to its credit, the present variety and that considered last in this paper. Murrill recognized that *P. distortus* had been badly

confused with *P. rufescens*, and says that a study of these forms in the field shows a very marked difference. He makes no allusion to a possible relationship with *P. biennis*.

Lloyd (1912) says that *Polyporus distortus* is a frequent plant in the United States, and that he believes it to be only a distorted form of *P. rufescens*. In fact he is so inclusive as to suggest that the form illustrated by Sowerby in his plate 191, Persoon's "Icones pictae" plate 6 [*P. acanthoides*], *P. rufescens*, *P. distortus*, and *P. heteroporus* are in reality all the same species. Two years later Lloyd (1914) declares that *P. biennis* and *P. rufescens* are synonymous. He makes no effort to discriminate, with regard to pore character and pileus coloration, between the normal American variety and its European relatives. I have examined specimens determined by Lloyd, and the only conclusion one can arrive at is that he based his interpretations upon those Berkeley and Curtis had already made with respect to American material, and not on any familiarity with European specimens of either *P. biennis* or its variety *Sowerbei*.

In spite of his inclusive synonymy Lloyd (1912 b) describes a fungus, with the same general characteristics but having large, round, shallow pores, as a new variety. He says that the upper surface of this fungus is not brown, but light colored and not distinctly pubescent. None of our normal American material is brown. This variety would seem to be based on a specimen that had matured with abnormal rapidity and lacking, as a consequence, the usual type of tissue and pore development. Lloyd, though usually quite critical, named this round-pored variation *P. rufescens* var. *hexagonoides*.

Among the later American mycologists the tendency is to maintain *Polyporus distortus* (Schw.) Fries, as a distinct species. Overholts (1914, 1915, 1933), Neuman (1914), Dodge (1914) and Lowe (1934) do not consider the possibility of a relationship between *P. distortus* and the European *P. biennis*. It seems better to me, in this case, to confess a relationship than to contend for autonomy. Specific integrity is based upon the teratological form while the very evident relationship is based upon the normally developed fungus.

4. *Polyporus biennis* (Bull.) Fries, var. *Ballouii* (Lloyd)
comb. nov.

Polyporus rufescens (Pers.) Fries, forma *Ballouii* Lloyd, Letter
49: 10. 1914.

Polyporus Ballouii Lloyd, Letter 58: 7. 1915.

Basidiocarp variable in form, frequently solitary, stipitate, sub-stipitate or sessile, sometimes resupinate; pileus fleshy-tough when fresh, somewhat coriaceous on drying, thin, plane, depressed or infundibuliform, circular or irregular in outline, sometimes imbricated, often much distorted, 2-10 cm. in diameter, 0.2-1 cm. thick; surface white to alutaceous, drying light tan or gray, compactly villose-tomentose, rarely approaching glabrous, azonate; margin variable, thin, usually fertile below, undulate or lobed; context white when fresh, drying isabelline to light tan, duplex, soft and fibrillose-spongy above, firm and corky below, 0.1-0.5 cm. thick; tubes decurrent, white, becoming isabelline on drying, rufescent when bruised, averaging 3-5 per sq. mm., angular to contorted, or irregular, rarely approaching circular, dissepiments thin, usually entire; stipe central to excentric or lateral, sometimes wanting, surface white, tomentose, soft on the outside, firm and leathery within, sometimes rudimentary or lacking; spores hyaline, smooth, $5-7 \times 3-5$ (6×4) μ , ellipsoid to broadly ovoid, apiculate, with a single guttation.

TYPE LOCALITY: New York.

HABITAT: About tree stumps, roots and in humus containing decaying wood of deciduous trees.

DISTRIBUTION: New York and Ohio.

ILLUSTRATIONS: Lloyd, Myc. Notes 69: pl. 236, fig. 2395, 2396. 1923.

Our var. *Ballouii* differs from var. *distortus* in the thinner and more leathery nature of its pileus, the smaller size of its pores and a somewhat greater range of spore size. The plant is usually smaller than the preceding variety. In this connection, however, it should be noted that the size of the plant which Lloyd (1923) figures is as large as that frequently attained by var. *distortus*, and helps fix this as a distinct variety by removing any prejudice toward the idea that var. *Ballouii* is merely a juvenile form.

Rufescent discoloration, it should be recognized, occurs frequently when this plant develops in an abnormal manner. A semi-

glabrous condition of the upper surface is often associated with a similar teratological state.

Lloyd (1914 b), in his first description of this fungus, designates it as forma *Ballouii*, and suggests that it is a variation of *Polyporus rufescens*, or possibly of *P. biennis*. Later (1915) he concludes that it is the same as Murrill's *Abortiporus tropicalis*, but that the name he has proposed is more appropriate and uses it in the specific sense.

Lloyd's descriptions are quite brief, and I have found it necessary to add a number of details. This makes more evident the relationship and differences between this variety and *Polyporus biennis*. As I see the situation, var. *Ballouii* is intermediate between *P. biennis* var. *distortus* and the next variety to be considered, with, possibly, a slightly closer affinity with the former.

5. *Polyporus biennis* (Bull.) Fries, var. *tropicalis* (Murr.)
comb. nov.

Abortiporus tropicalis Murr., Mycologia 2: 185. 1910.

Polyporus tropicalis (Murr.) Sacc. & Trott., Syll. Fung. 21:
277. 1912.

Basidiocarp variable in form, most often solitary, stipitate, sub-stipitate or sessile, sometimes resupinate, rarely imbricated or sub-caespitose through the branching of the stipe near the base; pileus spatulate to reniform when of lateral growth, subspatulate, circular, plane, depressed to infundibuliform when growing upright, sometimes much distorted, fleshy-tough when fresh, flexible, more rigid when dry, thin, $1-2 \times 2.5-3$ cm. in length and breadth, $0.2-0.4$ cm. thick; surface white to alutaceous, drying light tan or gray, finely tomentose, spongy, azonate; margin usually thin, undulate to lobed, sterile or fertile below; context white, isabelline or light tan on drying, duplex, soft and fibrillose-spongy above, firm and corky below; tubes decurrent, white, short, mouths minute, averaging 10-12 per sq. mm. glistening when fresh. dissepiments firm, obtuse to subacute, entire; stipe sometimes central, more often excentric, lateral or wanting, expanding into the pileus, irregular, up to 3 cm. long and 5-10 mm. thick, tomentose, soft on the outside, firm within; spores hyaline, smooth, ellipsoid to broadly ovoid, $4-7 \times 2-6$ (6×4) μ , apiculate.

TYPE LOCALITY: Jamaica.

HABITAT: Stumps and roots of deciduous trees.

DISTRIBUTION: West Indies, Mexico and South America.

The spores of this variety show an even greater range in size than do those of the preceding. The pores are exceedingly small, and difficult to see when in the young, fresh state they, and the relatively thick dissepiments, are covered with a profusion of spores. This condition results in what is apparently a smooth, glistening surface. Spore production is exceedingly luxuriant for the size of the fungus. The pores are so small that they have lost all vestage of the daedaloid condition that is typical of *Polyporus biennis*.

KEY TO POLYPORUS BIENNIS AND VARIETIES

Characteristics in common: Basidiocarp simple to imbricate from a short stipe, or sessile; pileus convex, plane to depressed; surface tomentose to strigose, azonate; context white when fresh, duplex, upper layer spongy, lower firm and coriaceous; tubes decurrent; stipe subcentral to lateral; spores ellipsoid to broadly ovoid, $4-7.5 \times 2-6$ (6×4) μ , hyaline, smooth, apiculate.

1. Pilear surface colored2.
1. Pilear surface white to alutaceous, colored or blotched rufescent only in teratological material3.
 2. Upper surface flesh-colored to light reddish-brown in the center with wide white margin, scurfy-tomentose to strigose; tubes white, labyrinthiform or sinuate, 48 per sq. cm. ...1. *Polyporus biennis*.
 2. Entire surface ferruginous to rufescent-brown, upper strigose or tomentose to hispid; tubes sinuate to angular, 21 per sq. cm.
 2. var. *Sowerbei*.
3. Tubes 1-3 per sq. mm. white, angular, contorted or irregular; upper pilear surface compactly villose-tomentose3. var. *distortus*.
3. Tubes smaller than 1-3 per sq. mm. white4.
 4. Tubes 3-5 per sq. mm. angular to irregular, sometimes contorted; upper pilear surface compactly villose-tomentose
 4. var. *Ballouii*.
 4. Tubes 10-12 per sq. mm. round to angular, upper pilear surface finely tomentose5. var. *tropicalis*.

The above key is prefixed with a brief statement of characters held in common in order to present not alone differences but to emphasize the undoubted relationship of these fungi. While pore size and shape pass through a definite and consistent evolution, it should be noted that spore form remains unchanged. Though these have a fairly wide size range they are typically $6 \times 4 \mu$. Cognizance should be taken of the over emphasis placed upon teratological characters in previously published descriptions of sev-

eral varieties included here. The var. *Sowerbei* is naturally of a rufescent color throughout, while *Polyporus biennis*, and its other three varieties, only assume such coloration upon mechanical injury or the presence of other teratological conditions.

LITERATURE CITED

- Battarra, G. A. 1775. Fungorum agri ariminensis historia. 1-80. *pl.* 1-40.
- Berkeley, M. J. 1872. Notices of North American fungi. *Grevillea* 1: 33-39.
- & Curtis, M. A. 1856. A commentary on the synopsis fungorum in America boreali media degentium, by L. D. de Schweinitz. *Jour. Acad. Sci. Phila.* II. 3: 205-224.
- Bresadola, G. 1916. Synonymia et adnotanda mycologica. *Ann. Myc.* 14: 221-242.
- . 1931. *Iconographia mycologica* 20: *pl.* 951-1000.
- Bulliard, M. P. 1789. *Herbier de la France* *pl.* 433-480.
- Dodge, B. O. 1914. A list of fungi of Kewaunee County, Wisconsin. *Trans. Wis. Acad.* 17: 806-845.
- Fries, E. M. 1821. *Systema mycologicum* 1: 1-520.
- . 1838. *Epicrisis systematis mycologici* 1-610.
- . 1851. *Novae symbolae mycologicae* 1-120.
- . 1874. *Hymenomycetes europaei sive Epicriseos systematis mycologici editio secunda* 1-755.
- Hard, M. E. 1908. The mushroom, edible and otherwise. 1-609. *fig.* 1-504.
- Lloyd, C. G. 1912. Synopsis of the stipitate polyporoids. 95-208. *fig.* 395-500.
- . 1912. *Letter* 40: 1-8.
- . 1914. *Letter* 49: 1-16.
- . 1914. The named and misnamed specimens of the exsiccatae. *Letter* 52: 1-32.
- . 1915. *Letter* 58: 1-8.
- . 1923. *Mycological notes* 70: 1219-1236. *pl.* 250-264.
- Lowe, J. L. 1934. The Polyporaceae of New York State. *Coll. For. Bull.* 41: 1-142. *pl.* 1-2.
- Murrill, W. A. 1904. The Polyporaceae of North America, VIII. *Hapalopilus*, *Pycnoporus* and new monotypic genera. *Bull. Torrey Club* 31: 415-428.
- Neuman, J. J. 1914. The Polyporaceae of Wisconsin. *Wis. Geol. Nat. Hist. Surv. Bull.* 33: 1-206. *pl.* 1-25.
- Overholts, L. O. 1914. The Polyporaceae of Ohio. *Ann. Missouri Bot. Gard.* 1: 81-155.
- . 1915. Polyporaceae of the middle-western United States. *Wash. Univ. Stud.* 3: 1-83. *pl.* 1-8.
- . 1933. The Polyporaceae of Pennsylvania. *Penn. Agr. Exp. Sta. Bull.* 298: 1-28. *pl.* 1-2.

- Patouillard, N.** 1898. Catalogue raisonné des plantes cellulaires de la Tunisie. I-XXIV, 1-158.
- . 1900. Essai taxonomique sur les familles et les genres des Hyménomycètes 1-184. *fig. 1-74.*
- Persoon, C. H.** 1797. *Tantamen dispositionis methodicae fungorum* 1-76. *pl. 1-4.*
- . 1801. *Synopsis methodica fungorum* I-XXX, 1-706. *pl. 1-5.*
- . 1803. *Icones pictae rariorum fungorum* 1-14. *pl. 1-6.*
- . 1825. *Mycologia europaea* 2: 1-214. *pl. 13-22.*
- Purton, T.** 1821. A botanical description of British plants 3: 1-575. *pl. 12-38.*
- Quélet, L.** 1872. Les champignons du Jura et Vosges 1: 1-320. *pl. 1-24.*
- . 1886. *Enchiridion fungorum* 1-352.
- Rea, C.** 1922. British Basidiomycetes 1-799.
- Saccardo, P. A.** 1925. *Sylloge fungorum* 23: I-XXXII, 1-1036.
- Schaeffer, J. C.** 1763. *Fungorum qui in Bavaria et Palatinatu circa Ratisbonam nascuntur icones* 2: *pl. 101-200.*
- Schweinitz, L. D. de.** 1822. *Synopsis fungorum Carolinae superioris.* *Schr. Nat. Ges. Leipzig* 1: 20-131. *pl. 1 2.*
- . 1832. *Synopsis fungorum in America boreali media degentium.* *Trans. Am. Phil. Soc. II. 4:* 141-316.
- Secretan, L.** 1833. *Mycographie Suisse, ou description des champignons que croissent en Suisse* 2: 1-576.
- Sowerby, J.** 1799. Coloured figures of British fungi or mushrooms. *pl. 181-240.*
- . 1815. *Ibid. pl. 418-440.*
- Spegazzini, C. L.** 1899. *Fungi Argentini novi vel critici.* *Anal. Mus. Nac. Buenos Aires II. 6:* 81-365. *pl. 1-2.*
- . 1902. *Mycetes Argentinenses, II.* *Anal. Mus. Nac. Buenos Aires III. 1:* 49-89.
- Winter, G.** 1884. Die Pilze, in *Rabenh. Krypt.-Fl.* 11: 1-924.
- Withering, W.** 1796. A botanical arrangement of British plants III. 4: 1-418. *pl. 30.*

THE PERFECT STAGE OF BOTRYTIS CINEREA¹

J. W. GROVES² AND F. L. DRAYTON³

(WITH 1 FIGURE)

In the genus *Botrytis*, a number of species with well defined characters have been described and named, but one of the oldest specific names, *B. cinerea* Pers., has been applied to a loosely defined group of fungi, which develop the well known grayish-brown conidiophores and conidia, and large, black, flat sclerotia adhering closely to the substratum. Such forms are found on a great many plants, exhibiting various degrees of pathogenicity or living as saprophytes. Their common occurrence, widespread distribution, and often destructive effects have made them the subject of much investigation and a voluminous literature has grown up dealing with their parasitism, host range, physiology, and cytology.

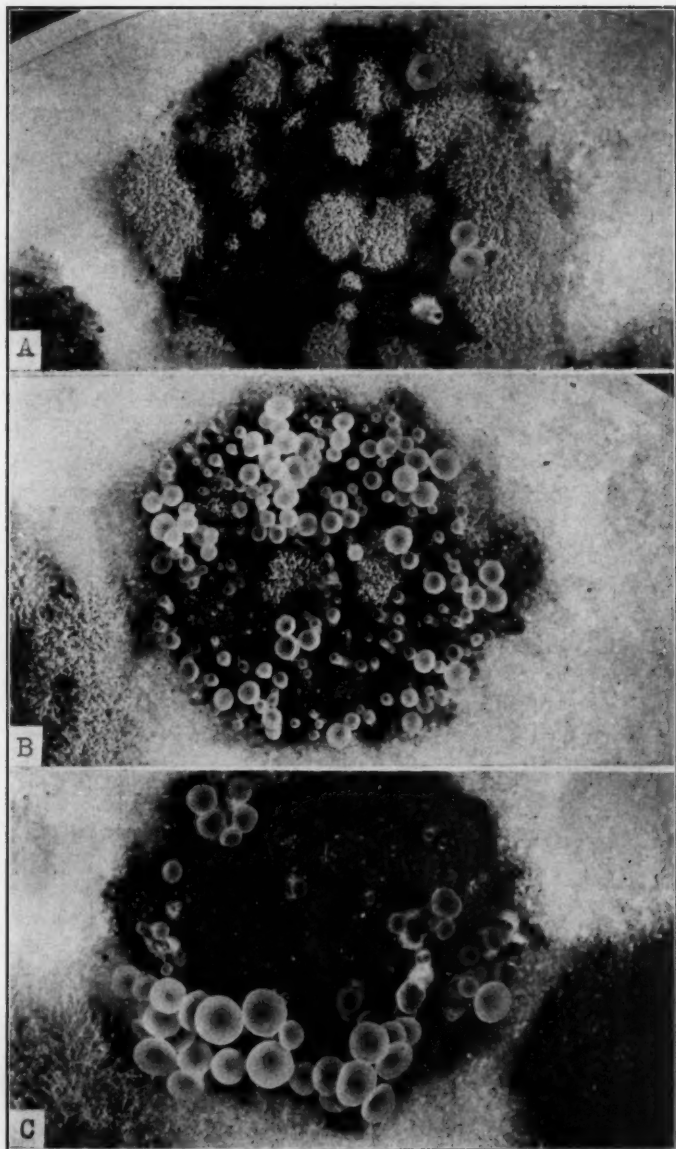
When these *Botrytis* forms are isolated, the cultures show an extraordinary range of variability in the production of sclerotia, appressoria, and conidia, in the rate of growth, and in the amount of aerial mycelium. In general, however, there is no option but to assign all these forms to the inadequately delimited species, *B. cinerea* Pers. and in the more recent literature one generally finds them regarded as a group, with each form being referred to as a *Botrytis* of the *cinerea* type.

The literature concerning the genetic connection of species of the genera *Botrytis* and *Sclerotinia* has been reviewed by Drayton (1937). Since this was written a *Sclerotinia* stage has been established by Gregory (1938) for *B. polyblastis* Dowson. Of the five recorded cases in which a genetic connection has been demonstrated by means of cultural technique, three of them, namely, *S. Ricini* Godfrey, *S. Porri* van Beyma Thoe Kingma, and *S. con-*

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voluta Drayton, have conidial stages of the *B. cinerea* type, while in *S. polyblastis* Gregory and *S. Geranii* Seaver and Horne, the conidia are quite distinct. In the three species of the *cinerea* type, the sclerotia and conidia are sufficiently characteristic to warrant specific separation from the large number of more closely related and intergrading forms with which every plant pathologist and mycologist is familiar. In the latter group, we have succeeded in developing, in certain isolates, a sexual stage belonging to the genus *Sclerotinia*.

For several years the junior author has been accumulating a collection of cultures of *B. cinerea* types. In this collection there were about seventy isolates from various hosts and localities and these were used in the attempts to obtain a perfect stage. In the first trial, the cultures were divided arbitrarily without regard to host, into eight groups, according to the gross appearance of the cultures. Representatives of each group were chosen and were cross-spermatized with members of other groups. No apothecia were obtained in this first experiment, but apothecial fundaments, which failed to mature, were observed in some isolates from apples and celery from cold storage and from potato plants collected in the field. In the next experiment all the available isolates from these three hosts, sixteen in all, were used, and from nine, mature apothecia were obtained.

The technique described by Drayton (1937) for the production of apothecia of *Sclerotinia convoluta* was followed, but with a few modifications. Spermatization was delayed until two weeks after the cultures had been moved from 0° to 5° C. and they were then put at 14° C. for one month prior to their transfer to the greenhouse. Two methods of spermatization were used. In the first, the spermatial suspension was applied directly to the sclerotia as described for *S. convoluta*. In the second, the suspension was used to moisten sterilized soil, which was then placed over the sclerotia. Apothecia were obtained with both methods, but the second was deemed preferable, because the soil helped to prevent

FIG. 1. Apothecia developed in culture from isolates of *Botrytis cinerea*. A, from apples in storage; B, from potato stems collected in the field; C, from celery in storage. Note the association of conidia and apothecia ($\times 1.5$).

excessive drying and also reduced conidial production. In addition, it was found that exposure to direct sunlight seemed to be harmful and better results were obtained when the cultures in the greenhouse were exposed only to north light.

On April 7, about 2 weeks after the cultures were moved to the greenhouse, the first mature apothecium was found. This was followed by the development of a great many more apothecia during the subsequent 6 weeks, after which the experiment was abandoned because of the high temperature in the greenhouse. Figures 1 to 3 illustrate some of the apothecia, with the accompanying conidiophores and conidia, obtained from isolates from the three host plants mentioned above.

The apothecia from the nine isolates discharged ascospores and about 20 single ascospore cultures were obtained from each isolate. In certain isolates the single ascospore cultures were uniform in their rate of growth, sclerotial production, and general appearance. In others, very marked differences were observed. Some of the cultures grew rapidly, producing a fluffy aerial mycelium, macroconidia, and eventually sclerotia, while others grew very slowly, forming a white, silky, aerial mycelium and never producing macroconidia or sclerotia, in fact they presented the appearance of cultures which we would ordinarily consider as staled. In most cases the cultures which did not produce sclerotia, developed abundant spermatia, but none has been observed in which a sclerotium-producing culture failed to produce spermatia.

The variation in the cultures obtained from single ascospores of the nine isolates cannot be explained from this experiment. The original isolations were made from conidia and sclerotia and it has been shown by Hansen and Smith (1932) that the conidia and hyphal cells of *B. cinerea* are multinucleate and that interchange of nuclei can take place by hyphal anastomoses. There could be no certainty therefore, that an isolate obtained in this way would possess nuclei of the same genetic constitution. In the single ascospore cultures, however, it can be assumed that all of the nuclei in each culture are of the same genetic constitution, thus providing homozygous material for experimentation.

The taxonomic significance of the development of sclerotinioid apothecia by some of the common forms of *B. cinerea* cannot be

properly evaluated at the present time, hence no change in nomenclature is proposed. Certain morphological differences are evident in the apothecia obtained and it is possible that there may be more than one species involved even in the comparatively few isolates used. The work now in progress with the cultures of single ascospore origin will, no doubt, give some clue to the interpretation of the numerous variations observed and help to clarify the species concept in this perplexing group of fungi.

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LITERATURE CITED

- Drayton, F. L.** The perfect stage of *Botrytis convoluta*. *Mycologia* 29: 305-318. 1937.
- Gregory, P. H.** *Sclerotinia polyblastis* n. sp. on *Narcissus* the perfect stage of *Botrytis polyblastis* Dowson. *Trans. Brit. Myc. Soc.* 22: 201-203. 1938.
- Hansen, H. N. & Smith, R. E.** The mechanism of variation in imperfect fungi. *Phytopathology* 22: 953-964. 1932.

TWO NEW SPECIES OF RUSSULA TOGETHER WITH THE SPORE ORNAMENTATION OF SOME OF OUR AMERICAN RUSSULAS

GERTRUDE S. BURLINGHAM

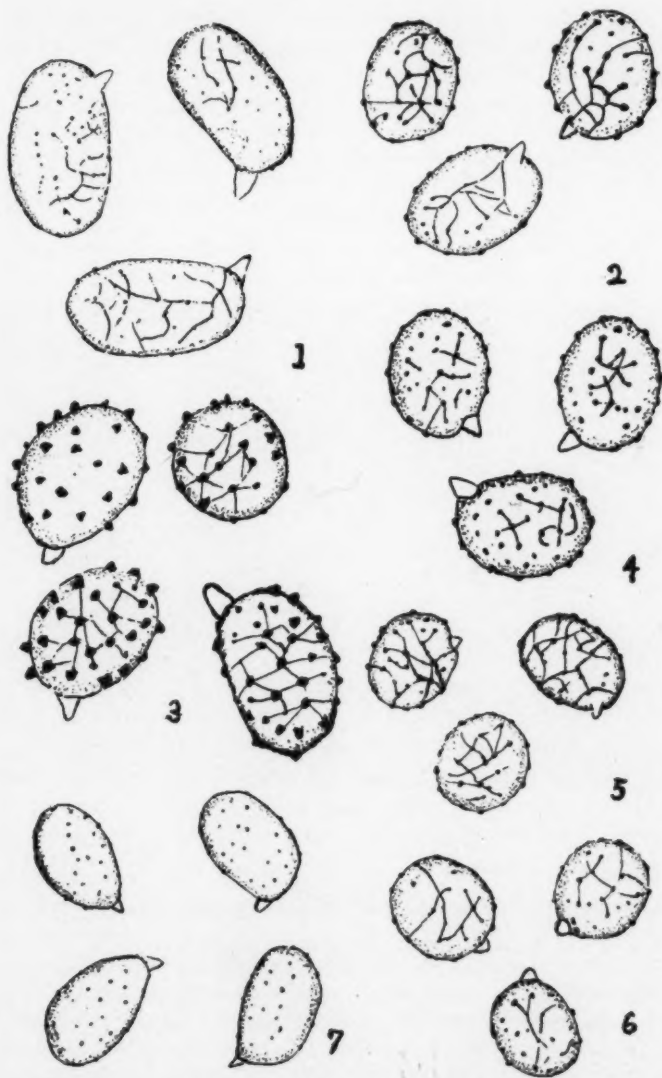
(WITH FOURTEEN FIGURES)

It is a great pleasure to find a species of *Russula* with some distinctive characteristic which makes its identification easy and positive. Such was a red *Russula* collected near Longwood, Florida, in November 1935. In the field, however, it appeared to be a common species, but when the spores were examined under the oil immersion with an iodine stain, they were found to be similar to the spores of *Russula heterospora* described by H. C. Beardslee in *Mycologia* 26: 259. 1934. Since my first collection the weather conditions have not been right for the growth of the species during the fall season until this November of 1938 when following warm rainy weather it again appeared in the same woods and I was able to obtain a photograph. The species grows in the same woods where Mr. Beardslee found the type specimens of *Russula heterospora*. Since Mr. Beardslee kindly gave me access to his choice collecting grounds, and in recognition of his extensive work on this genus, I have chosen this specific name.

***Russula Beardslei* sp. nov. (FIG. 1, 10).**

Pileus peach red,¹ sometimes fading to incarnate on the margin, glabrous, viscid when wet, with cuticle separable on the edge, up to 8 cm. broad; margin becoming obscurely striate-tuberculate; context white except tinted red next the surface of the pileus, unchanging, bad tasting then slowly peppery, no special odor; lamellae fleshy-white tone 4 singly, a few scattered incomplete ones, some forking next the stipe but mostly simple, broad, rounded near the stipe then attached by a decurrent tooth; stipe white, firm becoming spongy, nearly equal except spreading at the apex and rounded off at the base, 6 cm. \times 1.5–1.8 cm.; spores

¹ Repertoire de Couleurs.



FIGS. 1-7. Spore markings of some American russulas. 1, *R. Beardslei*; 2, *R. insignita*; 3, *R. Ballouii*; 4, *R. corallina*; 5, *R. blanda*; 6, *R. flocculosa*; 7, *R. ventricosipes*.

honey yellow tone 1 in. thick mass, $6.25-6.87 \mu \times 10-12 \mu$ with very minute protuberances arranged in lines or with fine connecting lines, apiculate, unsymmetrical.

Pileo rubro, jove pluvio viscido, pellicula subseparabile, margine demum striato; lamellis pallidis, simplicibus, subaequalibus, proxime stipitem leviter rotundatis et adnectis decurrente dente; stipite albo, 6 cm. \times 1.5-1.8 cm.; carne albo, sapore male dein tarde acri; sporis melleis, $6.25-6.87 \mu \times 10-12 \mu$.

TYPE LOCALITY: Longwood, Florida.

HABITAT: On the ground in sandy soil in live oak woods.

While having the same elongated spores noted in *Russula heterospora* it differs in the color of the spores, the taste of the



FIG. 8, spores of *R. astringens*; 9, spores of *R. admirabilis*.

context, the color of the pileus, and the practically simple lamellae.

The following species has been found for several years by Mr. Beardslee growing on a lawn near Longwood, Florida, and it has occurred rather abundantly after rains each year since I have been collecting in this locality.

***Russula admirabilis* sp. nov.** Beards. & Burl. (FIG. 9, 11).

Pileus rather firm, broadly convex becoming centrally depressed, coppery red tone 1-4, or old blood red, with the central area pale flesh to pale ecru or sometimes nearly white, densely pruinose at first, sometimes becoming pruinose-granular, viscid when wet, cuticle separable up to the disc, 4.2 cm. to 8 cm. in diameter; margin even becoming obscurely striate-tuberculate on the extreme edge; context white, unchanging, mild without special odor; lamellae pure white at first, becoming pale ecru 66 tone 4, equal, broad, simple, rounded on approaching the stipe and depressed,

then narrowly attached; stipe white, nearly equal, rather firm to spongy with maturity, 3.5 cm. \times 1-1.5 cm.; spores honey yellow 35 tone 2, $6.5 \mu \times 8-8.75 \mu$, reticulate with small protuberances of different sizes connected by fine bands and lines, apiculate and unsymmetrical.

Pileo firmulo, e convexo depresso, cupro-rubro margine, disco pallido, primo pruinoso, jove udo viscido; margine laevi, exoleta striatulo, 4.2 cm. to 8 cm.; carne albo, miti; lamellis ex albo pallidis, aequalibus, simplicibus, postice rotundatis; stipite albo firmulo curto; sporis melleis, reticulatis, $6.5 \mu \times 8-8.75 \mu$.

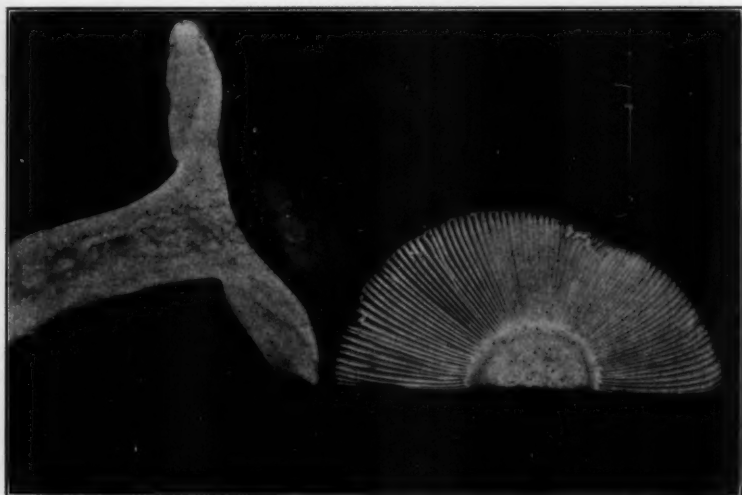


FIG. 10. *Russula Beardslei*, No. 7—Nov. 16, 1938. $\frac{3}{4}$ natural size.

TYPE LOCALITY: Longwood, Florida.

HABITAT: In grass on a lawn with scattered trees of *Pinus palustris* near.

The stipe is so short that the pileus sets close to the ground. The incarnate to coppery red margin and pallid center, mild taste and white lamellae becoming only pale ecru will serve to distinguish it in the field; while the spore color and markings will clearly separate it from *Russula rosea* Quél. and *Russula lutea* var. *armeniaca* (Cooke) Rea or *Russula chamaeleontina* Fries, or *Russula amygdaloides* Kauff. From *Russula aurora* Krombh. it dif-

fers in the persistently mild taste, simple lamellae, smaller size, separable pellicle, and shape and size of the spores.

Much confusion has arisen in the genus *Russula* because of the failure to give in the type description the color of the spores as based upon a dense spore print. In addition to the spore color so obtained, a camera lucida drawing of spores treated with the iodine solution recommended by Crawshay² should accompany every original description, since the spore ornamentation is often the final means of identification. Because of this importance of the spore markings, and in view of the fact that all of our species de-

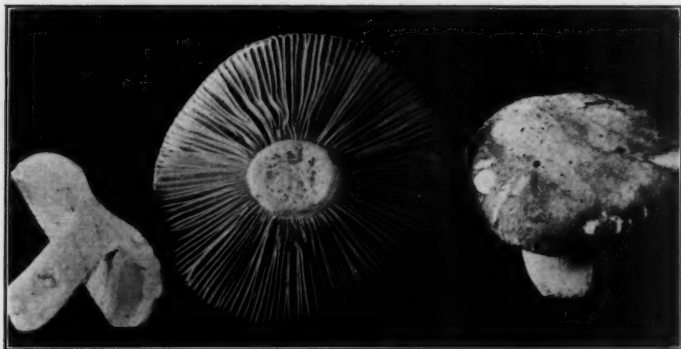


FIG. 11. *Russula admirabilis*, type. Natural size.

scribed prior to the last few years have lacked drawings of the spore ornamentation as brought out with the iodine stain, I have undertaken to make a series of plates showing the spore ornamentation of our American species of *Russula*, using spores from the type collection wherever possible. If photographs of a species have never been published, they will be included if available.

The photograph of *Russula ventricosipes* Peck was taken from specimens found at Yarmouthport, Cape Cod, Mass., under pines. The species has a superficial resemblance to *Russula foetens* Fries. Specimens were found growing in abundance, the pileus reaching a diameter of from 12 to 15 cm. in diameter. When not bruised in coming through the sand, the stipe would be nearly white, but

² Spore Ornamentation of the Russulas, p. 72.

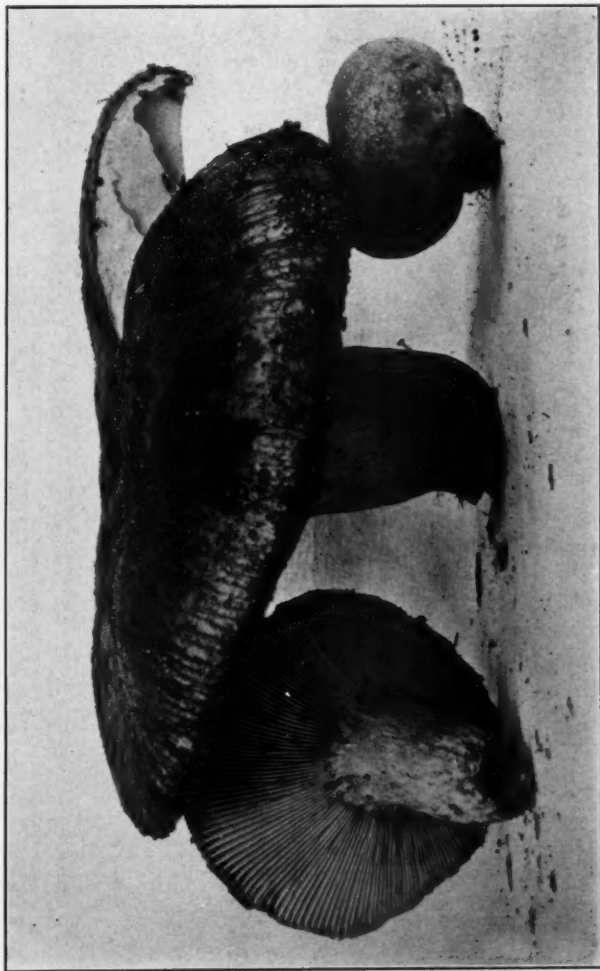


FIG. 12. *Russula ventricosipes* Peck. Natural size.

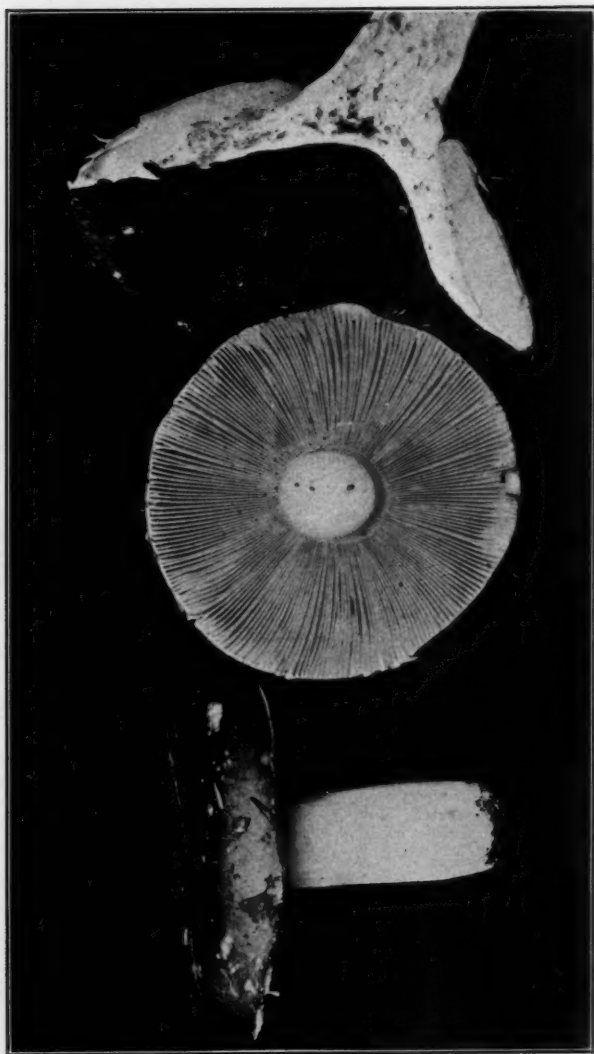


FIG. 13. *Russula astringens* Burl. $\frac{2}{3}$ natural size.

otherwise or where handled the stipe became red due apparently to an exudation from glandular like dots. While stout the stipe is comparatively short. The spores are very distinctive, as shown in figure 7.

The photograph of *Russula astringens* Burl. was made from specimens growing on Newfane Hill, Vermont. The species is rather common along wooded roadside under white birches or in deciduous woods containing white birches. *Russula Ballouii* was photographed from specimens collected with W. H. Ballou from the type locality on Staten Island, N. Y.



FIG. 14. *Russula Ballouii* Peck. Natural size.

***Russula insignita* nom. nov.**

In North American Flora 9: 212. 1915, I described a new species of *Russula* under the name of *Russula insignis*. Since then I have learned that Quélet had applied that name to another species of *Russula* (Ass. FR. 1887), and it becomes necessary to give another name to my species. In addition to the localities where Mr. Simon Davis collected it, I have found it growing on the grounds of Wellesley College, Mass. This species differs from *Russula farinipes* Rom. in the mild taste, more even margin, and the difference in size, shape and markings of the spores. It does not seem to be related to the Pectinatae group.

EXPLANATION OF FIGURES

FIG. 1. Spores of *Russula Beardslei*; $6.25-6.87\ \mu \times 10-12\ \mu$ with very minute protuberances arranged in lines or connected by fine lines, apiculate and unsymmetrical.

FIG. 2. Spores of *Russula insignita*, drawn from type; $6-6.87\ \mu \times 7.5-8\ \mu$ exclusive of apiculus, with small protuberances of different sizes, some connected by fine lines, apiculate and unsymmetrical.

FIG. 3. Spores of *Russula Ballouii* Peck; $7-8\ \mu \times 8-10\ \mu$, rarely $10\ \mu$. Under $\frac{1}{6}$ power they appear echinulate. At first under the oil immersion stained with iodine they appear only echinulate, but when the iodine is washed out, very fine lines like spider's web show connecting some of the spines.

FIG. 4. Spores of *Russula corallina* Burl. from the type; $6.25-7\ \mu \times 7.5-8.7\ \mu$ with small tubercles of different sizes, some connected by fine lines, apiculate and unsymmetrical.

FIG. 5. Spores of *Russula blanda* Burl. from the type; the measurement of the spores at this time gives a smaller size than when fresh, $5-6.25\ \mu \times 6.25-7.5\ \mu$ with small protuberances, many connected by fine lines.

FIG. 6. Spores of *Russula flocculosa* Burl. from the type; $5-6.25\ \mu \times 6.25-6.87\ \mu$, nearly globose with very small protuberances, some of which are connected by fine lines, apiculate and somewhat unsymmetrical.

FIG. 7. Spores of *Russula ventricosipes* Peck; $5-6.25\ \mu \times 8-10\ \mu$, apparently smooth without the iodine stain, but with it very minute granular-like protuberances appear, apiculate and unsymmetrical.

FIG. 8. Spores of *Russula astringens* Burl.; $5-6\ \mu \times 7-8\ \mu$. These spores were drawn on a larger scale than those in the other figures. A few scattered protuberances occur, some connected by fine lines, apiculate and somewhat unsymmetrical.

FIG. 9. Spores of *Russula admirabilis* Beards. and Burl.; $6.5\ \mu \times 8-8.75\ \mu$ with scattered small tubercles connected by lines, apiculate and somewhat unsymmetrical.

FIG. 10. *Russula Beardslei*. No. 7. Nov. 16, 1938. $\frac{9}{10}$ natural size.

FIG. 11. *Russula admirabilis*. Type. Natural size.

FIG. 12. *Russula ventricosipes* Peck. Natural size.

FIG. 13. *Russula astringens* Burl. $\frac{2}{3}$ natural size.

FIG. 14. *Russula Ballouii* Peck. Natural size.

PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXXIII. A NEW BOUDIERA

FRED J. SEAVER

(WITH 1 FIGURE)

The genus *Boudiera* was established by M. C. Cooke in 1877, the type species being *Boudiera areolata* Cooke & Phillips, described from material collected in North Wales. The name *areolata* was misleading, since the spores are echinulate rather than areolate. Little seems to have been known of this genus until the writer in 1904 collected in abundance a species in Iowa which is similar if not identical with the European *Boudiera areolata*. This was erroneously described as a *Sphaerosoma* owing to the fact that *Boudiera areolata* had been misinterpreted and misrepresented in the records which were at that time available. Not until 1914, through the examination of an authentic specimen, was the writer able to determine the true characters of the genus *Boudiera*. When this was done it was found that *Sphaerosoma echinulatum* of the writer was only another form of *Boudiera*, so closely resembling the type species that it is even doubtful if the two are distinct, but since there are certain gross characters which appear to differ the two species have been retained in our recent monograph of the operculate cup-fungi.

Recently the writer has received from Dr. Leva B. Walker of Nebraska a beautiful specimen which is unquestionably a *Boudiera*. While the general characters leave no question as to its generic identity, its specific characters differ greatly from the other two described species. The apothecia of *Boudiera areolata* attain a diameter of 5-8 mm. and were dark-brown in color, while the present species from Nebraska is scarcely a mm. in diameter and pure white. Both are characterized by the strongly protruding asci and paraphyses which give to the convex subhemispherical hymenium a much roughened appearance. Apothecia of the Nebraska mate-

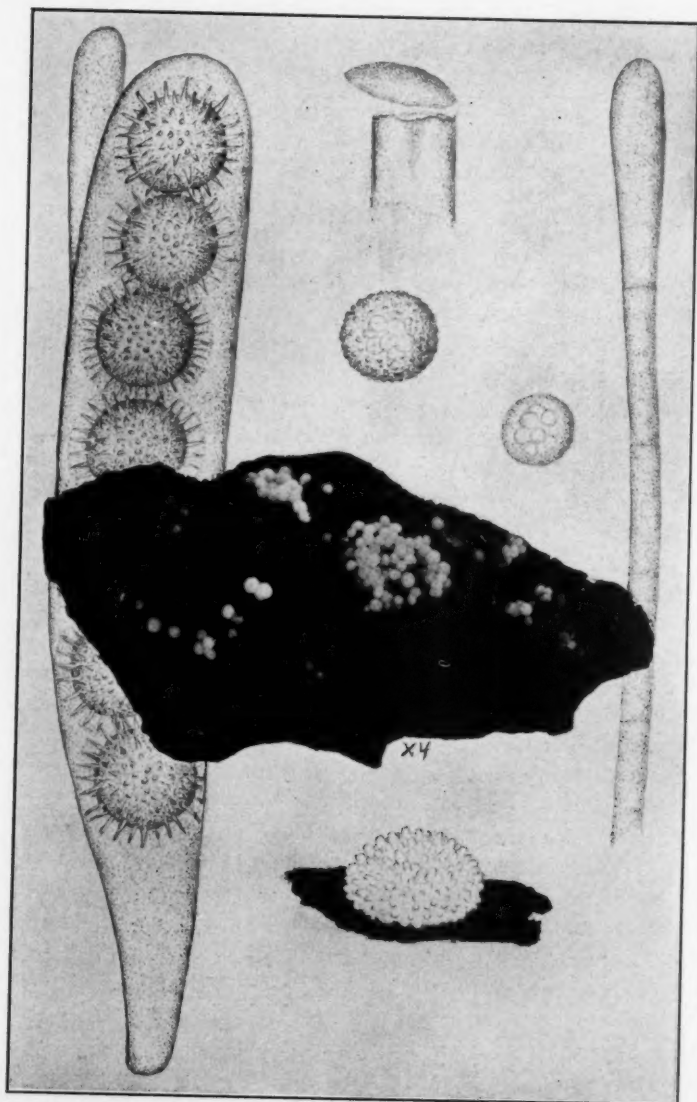


FIG. 1. *Boudiera Walkerae*.

rial appear as minute white cushions, as shown in the accompanying photograph. The asci are only half as long as those in *Boudiera echinulata*, but the spores themselves are almost identical except that they are possibly a trifle smaller. In general characters the present species is so distinct from the two formerly described that it must be regarded as new to science.

The present species is dedicated to the collector, who found these beautiful plants growing on a pan of soil on which she was testing the growth of some other organism. There was one large group, as shown in accompanying photograph. The fungus according to the collector, did not continue to reappear, but gradually disappeared soon after the collection of these specimens.

***Boudiera Walkerae* sp. nov.**

Apothecia gregarious, sessile, at first subdiscoïd soon expanding and becoming rounded and cushion-like with the ends of the huge asci protruding and giving the surface roughened appearance, entirely white reaching a diameter of 1 mm.; asci clavate, reaching a length of $225\ \mu$ and a diameter of $40\ \mu$, 8-spored; spores at first irregularly disposed, finally becoming 1-seriate, at first smooth and filled with large oil drops, the surface gradually becoming roughened, the roughenings finally assuming the form of long spines, reaching a diameter of $25\text{--}30\ \mu$ including spines, or $18\text{--}20\ \mu$ exclusive of spines, hyaline; paraphyses clavate reaching a diameter of $15\ \mu$.

Apotheciis gregariis sessilibus demum convex-hemisphaericis, albidis 1 mm diam.; ascis clavatis, $225 \times 40\ \mu$; octosporis; sporiis demum monostichis perfecte sphaericis initio levibus, pluriguttulatis demum spinulosis, hyalinis, $25\text{--}30\ \mu$ diam.; paraphysibus clavatis, hyalinis, $15\ \mu$ diam.

On bare soil in the laboratory.

TYPE LOCALITY: Lincoln, Nebraska.

DISTRIBUTION: Known only from the type locality.

In this species the asci open by means of an operculum, characteristic of the group. After the discharge of the spores the asci themselves partially collapse while the operculum seems to keep approximately its original size; so that the lid of the emptied asci appears to be too large for the ascus, as indicated in the sketch. This is just the reverse of conditions found in some of the other operculates in which the lid is very much smaller than the diameter of the ascus, even after the spores are discharged.

THE NEW YORK BOTANICAL GARDEN

NOTES AND BRIEF ARTICLES

NEW SPECIES OF TAPHRINA

In a recent paper (Jour. Wash. Acad. Sci. 29: 222-230. 1939) Dr. Anna E. Jenkins of the Bureau of Plant Industry, Washington, D. C., has described two new species of *Taphrina* on native North American maples under the names *Taphrina Dearnessii* and *Taphrina Carveri*. Dr. Jenkins is expected to write the Exoascales for North American Flora, and this article is another contribution to our knowledge of this group.—FRED J. SEAVER.

FLORA AGARICINA DANICA

Volume 4 of this superb work has recently appeared. In this volume the following genera are treated, with the number of species and varieties indicated in parentheses: *Flammula*, (14); *Naucoria* (31); *Tubaria* (7); *Galera* (30); *Bolbitius* (1); *Pluteolus* (2); *Crepidotus* (7); *Paxillopsis* (6); *Paxillus* (4); *Psalliota* (19); *Stropharia* (23); *Lacrymaria* (4); *Hypholoma* (15); *Psilocybe* (12); *Panaeolus* (9); *Psathyra* (30); *Pseudocoprinus* (2); *Coprinus* (35). This volume is illustrated with 39 plates, each containing many figures in color.—FRED J. SEAVER.

LICHENS OF THE ANTARCTIC

A report of the "Lichens and Lichen Parasites" of the Second Byrd Antarctic Expedition is published in the Annals of the Missouri Botanical Garden (25: 515-727). The work has been prepared by Dr. Carroll W. Dodge, Mycologist to the Missouri Botanical Garden, and Professor in the Henry Shaw School of Botany of Washington University, and Dr. Gladys E. Baker, Instructor in Botany, Hunter College, and formerly Research Assistant, Henry Shaw School of Botany of Washington University, and has been accomplished with the coöperation of the Botany

Department of the University of Iowa. More than 80 new species are described in this extensive contribution, and these are illustrated in 27 plates, containing 431 figures. This is the largest contribution ever made to the lichen flora of the Antarctic.—FRED J. SEAVER.

GNOMONIA ULMEA

We have recently received a copy of Contributions de l'Institut Botanique de l'Université de Montréal. No. 3. pp. 1-139. Pls. i-xxx. 1938. "Recherches sur le *Gnomonia ulmea* (Schw.) Thüm." by Dr. René Pomerleau.

Dr. Pomerleau's studies are included under three heads: The Biology, Ecology, and Cytology of the elm leaf fungus *Gnomonia ulmea*. This work constitutes the most extensive study yet made of this parasite of the elm. The fungus is endemic in America and according to the author has not yet been found in Europe or Asia. A very detailed study has been made of the life history of the organisms and the method of dissemination and germination of the ascospores, the steps in primary infection, the production and dissemination of conidia and secondary infection by these conidia. The cytological observations include a study of the mycelium, the development of acervuli and the stromata. Having been a former student of the celebrated Prof. Dangeard of Paris, Dr. Pomerleau would naturally be inclined to give special attention to the origin and development of the perithecium. In all, 22 plates are given over to illustrations of various stages in the development of the fungus. He finds only one nuclear fusion and only one reduction. The author concludes as a result of his studies that the ascomycetes are a monophyletic group.—B. O. DODGE.

MICHIGAN MUSHROOMS

A manual of the "Common edible and poisonous mushrooms of southeastern Michigan" has recently been issued by the Cranbrook Institute of Science. The manual has been prepared by Dr. Alexander H. Smith of the University of Michigan, and is designed to supply a local demand, but need not be restricted to local use for

it is suited to the needs of amateur mycophagists in any part of North America. Only about one-tenth of the forms known to occur in Michigan are treated. However, the most outstanding edible and poisonous species are described and beautifully illustrated in its sixteen halftone plates. The work may be had in either paper or cloth. Further information may be secured by writing the author of the manual, indicated above.—FRED J. SEAVER.

PODAXIS AEGYPTIACA

The interesting note on the distribution of *Urmula Geaster* in the current number of *Mycologia*, page 367, suggested by offering the following communication.

In April, Howard Dearness observed what he took to be two unlike species of stemmed puff-balls. They inhabited sandy desert tracts separated considerable distances from Alyce Springs in central Australia where the noon-day temperature reaches 120° F. He sent me a selected typical specimen of each both similarly releasing spores at the base of the peridium. One of them agreed with the description and herbarium material of *Podaxis pistillaris*. The other, a smaller, smoother and more slender plant was exactly like C. G. Lloyd's photo, No. 25, of *Podaxis aegyptiaca* Mont.

Under this name two descriptions are given in Saccardo's *Sylloge* in vol. 7: 58 and vol. 23: 589 differing a good deal in the size and somewhat in other terms, but nearly agreeing in the color of the glebal mass—"ferruginea rubra" and "aurantio-cinnamomei." The most striking macroscopic difference between the two specimens received was in the color of the glebal mass, that of the small one a peculiar bright rusty red.

P. aegyptiaca, if a valid species, is a widely distributed one, being reported from Asia, Africa, America and Australia and ranging from 30° N. to 30° S. of the equator. Although the color of the ripe gleba is apt to attract notice it is rarely reported judging from the records available to me. Respecting the validity of the species it should be noted that Miss E. E. Morse in a very careful study of *Podaxis* (*Mycologia* 25: 1-33. 12 plates), arrives at the conclusion that every specimen that she has examined is referable to

Podaxis pistillaris. She records 25 names that she has reduced to this one and strongly implies that nearly as many more, including *P. aegyptiaca*, should share the same fate. The two specimens under notice do seem however to be different species; and yet if every existing variation could be placed between them the gap might be filled.—JOHN DEARNESS.

STUDIES ON THE AGARICACEAE OF HOKKAIDO

A comprehensive work under the above title has been published by S. Imai, in parts 1 and 2 of Volume 43 of the Journal of the Faculty of Agriculture, Hokkaido Imperial University, Sapporo, Japan. Three hundred and forty-eight species and forms are considered in detail, including important literature citations, synonymy, distribution, and an adequate description in English for each. Forty species, and three forms are described as new. In addition new combinations are made in the case of eighteen species and three forms, with one new name proposed. The author sets up six new subfamilies, fifteen tribes, fifteen subgenera, nine sections and four subsections. Of the 348 species and forms studied in Hokkaido, 233 are also reported from Europe and North America, 49 from Europe only, 23 from North America, while 43 are endemic or eastern Asiatic.

It is of interest to note that the author finds a considerable number of the forms studied intermediate between European and North American species. 196 of the species and one form are new to the flora of Japan.

181 species and four forms are considered edible, of which 74 species and two forms are suitable for market. A list of seventeen poisonous species is given. Approximately 50 of the species are illustrated. Adequate specific and generic keys as well as for large groups are provided.—JOHN A. STEVENSON.

THE BULGARIA QUESTION

In adopting Fries' *Systema Mycologicum* as the starting point for the nomenclature of the fungi, as provided in the International Rules, confusion frequently results through the fact that Fries had

little knowledge of the microscopic characters of the fungi, and frequently species were grouped together in the same genus which had no close relationship, other than a superficial resemblance. A good illustration of this is the genus *Bulgaria*, which was established by Fries with *B. globosa*, an operculate species, as the first species mentioned and therefore regarded as the type. In the same genus he included *B. inquinans*, an inoperculate species. Since these cannot possibly be regarded as congeneric in present day treatments the writer in North American Cup-fungi retained the name *Bulgaria* with *B. globosa* as the type (Seaver, N. Am. Cup-fungi 194. 1928), while the name *Phaeobulgaria* was proposed (Mycologia 24: 253. 1932) for the inoperculate species typified by *B. inquinans* with its brown spores. This classification was adopted by Nannfeldt in his "Studien über die Morphologie und Systematik der Nicht-Lichenisierten Inoperculaten Discomyceten" (Nova Acta Reg. Soc. Sci. Upsal. IV. 8: 310. 1932).

Recently a Japanese student, Yosio Kobayasi, in a brief paper "On the gelatinous cup fungi, *Bulgaria*-group" (Jour. Japanese Bot. 13: 40. 1937) has reversed this treatment, and now proposes retaining *Bulgaria* for the inoperculate species, while the old untenable name, *Sarcosoma*, is resurrected for the operculate forms. While the writer, unfortunately, is unable to read the Japanese discussion leading up to these conclusions, it is very doubtful if this suggestion will be followed by American and European students of Discomycetes, since it is a violation of the International Rules of Nomenclature, and also reverses modern current usage.—
FRED J. SEAVER.

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